isnar

International Service for National Agricultural Research

Financing Agricultural Research: A Sourcebook

Steven R. Tabor ▪ Willem Janssen ▪ Hilarion Bruneau

The International Service for National Agricultural Research (ISNAR) assists developing countries in bringing about lasting improvements in the performance of their national agricultural research systems and organizations. It does this by promoting appropriate agricultural research policies, sustainable research institutions, and improved research management. ISNAR's services to national research are ultimately intended to benefit producers and consumers in developing countries and to safeguard the natural environment for future generations.

ISNAR offers developing countries three types of service, supported by research and training:

- For a limited number of countries, ISNAR establishes long-term, comprehensive partnerships to support the development of sustainable national agricultural research systems and institutions.
- For a wider range of countries, ISNAR gives support for strengthening specific policy and management components within the research system or constituent entities.
- For all developing countries, as well as the international development community and other interested parties, ISNAR disseminates knowledge and information about national agricultural research.

ISNAR was established in 1979 by the Consultative Group on International Agricultural Research (CGIAR), on the basis of recommendations from an international task force. It began operating at its headquarters in The Hague, the Netherlands, on September 1, 1980.

ISNAR is a nonprofit, autonomous institute, international in character and apolitical in its management, staffing, and operations. It is financially supported by a number of the members of the CGIAR, an informal group of donors that includes countries, development banks, international organizations, and foundations. Of the 16 centers in the CGIAR system of international centers, ISNAR is the only one that focuses specifically on institutional development within national agricultural research systems (NARS).

Financing Agricultural Research: A Sourcebook

Edited by

Steven R. Tabor
Willem Janssen
and
Hilarion Bruneau

April 1998

isnar
International Service for National Agricultural Research

Copyright 1998 by the International Service for National Agricultural Research (ISNAR).
All rights reserved.
ISNAR encourages the fair use of this material. Proper citations requested.

Citation

Tabor, S.R., W. Janssen, and H. Bruneau, (Eds.). 1998. Financing Agricultural Research: A Sourcebook. The Hague: International Service for National Agricultural Research.

AGROVOC Descriptors

agriculture; research; financial; policies; public research; cooperation; regional development; development agencies; private loans

CABI Descriptors

agricultural research; agricultural financial policy; research support; public sector; cooperation; development agencies; private loans; regional policy

Geographical Descriptors

Africa; Asia; Australia; Latin America

ISBN: 9 911 03 1

Contents

Part 2. Resource Mobilization and Accountability

Figures

Tables

Foreword

Agricultural research systems are coming under grave financing pressure. In the developing world, growth in agricultural research staff has far exceeded the supply of funds that the poorer countries have been able to allocate to their research effort. Political neglect, over-reliance on donor assistance, and ineffective use of existing resources have contributed to and are compounding the developing world's funding dilemma.

But funding problems are by no means confined to the agricultural research systems of the low-income nations. As the governments of OECD countries reduce public expenditures, and as corporate R&D spending concentrates on a smaller number of leading institutes, the agricultural research systems of the North are also experiencing financial distress.

The financing problems of the world's agricultural research systems must be addressed. Without adequate support, the new knowledge and technology needed to meet the challenges of hunger, poverty, and economic growth will simply not be forthcoming. Lasting solutions to the funding problem will differ from country to country, but they will undoubtedly involve a mixture of better policies, more innovative and entrepreneurial planning and resource mobilization, and a vast improvement in financial management.

This ISNAR book compiles experience, analysis, and advice for addressing the funding problems of agricultural research systems in the developing countries. It addresses a range of issues in financial policy, planning, and management. The list of topics covered is not exhaustive, and the lessons drawn from experience in one setting may or may not prove of value in another. However, urgent efforts are needed to resolve the financial crisis of the developing world's national agricultural research systems. This book is intended as a guide to the policy makers and research leaders involved in this process.

Many authors, from ISNAR and other institutions, have contributed their ideas and experience to this volume. On behalf of ISNAR, I wish to acknowledge their contributions and I extend my profound thanks to them.

We must all join forces to engineer lasting improvements in the funding environment for the national agricultural research systems of the developing world. ISNAR dedicates this book to the concerted pursuit of this goal and, as a member center of the CGIAR, stands ready to do its part.

We call on developing-country leaders and their partners in the North to commit themselves to rebuilding the funding base for agricultural research so that it matches the sobering challenges of the 21st century.

Stein W. Bie
Director General
ISNAR

Acknowledgements

The development of this book owes much to the encouragement and support provided by ISNAR's management. This endeavor was initiated by former director general Dr. Christian Bonte-Friedheim and brought to fruition under the tenure of Dr. Stein W. Bie. Dr. Bonte-Friedheim was acutely distressed by the emergence of financial shortfalls in national agricultural research systems. He worried especially about the growing disparity between the challenges facing the NARS and the financial resources at their disposal. At his urging, the editors have undertaken to produce a volume that marshals facts, lessons learned, and practical advice for those seeking to solve agricultural research funding problems.

Almost all of ISNAR's professional staff participated in this task at one time or another, and the editors would like to express their acknowledgement and gratitude for their cooperation and contributions. Several ISNAR staff authored chapters and cooperated patiently with the editors as chapter drafts evolved to become the products presented in this volume. Other authors, from development banks, other CGIAR centers, universities, NARS, NGOs, and the private sector, generously donated their time and effort towards this effort. Without their special expertise, it would have been difficult to do justice to many important topics.

The sourcebook benefited from the guidance of a steering committee. Our thanks are extended to Louk de la Rive Box, Kwame Akuffo-Akoto, Claudio Cafati, Faiz Mohideen, Amir Muhammed, Cyrus G. Ndiritu, R.S. Paroda, Gabrielle J. Persley, and Martin Piñeiro for their participation on this committee.

Many colleagues at the World Bank, the Inter-American Development Bank, IFPRI, CIRAD, and in the NARS offered constructive comments and suggestions on the material as it developed. The book also received a thorough mid-course review from an expert advisory team, whose comments helped the editors immensely to sharpen and refocus the final volume. Special thanks are extended to Frank Ellis, Rolf G sten, Barry Nestel, and Ammar Siamwalla for their excellent review.

Throughout this endeavor, ISNAR's editorial staff has offered its strong support. Free-lance editor Gerry Toomey and Jan van Dongen spent many hours editing and overseeing the publication, Fionnuala Hawes provided the desktop publishing, Richard Claase prepared the design and artwork, and Kathleen Sheridan supervised the overall publication effort.

But with so many actresses and actors involved, the publication would not have reached this stage were it not for the sustained, cooperative and creative secretarial support that we received. We are especially grateful to Cockie Kuyvenhoven, Melina Tensen, and Marie-Rose Stanek for keeping this multi-faceted effort on-course.

Steven R. Tabor
Willem Janssen
Hilarion Bruneau

Contributors

Gary Alex
United States Agency for International Development
1818 H. Street, N.W.
Washington, DC 20433, USA.,
Fax: +1 202 4776391

Henning Baur
International Service for National Agricultural Research
P.O. Box 93375
2509 AJ Hague
Netherlands
Fax: +31 70 3819677

Hilarion Bruneau
International Service for National Agricultural Research
P.O. Box 93375
2509 AJ The Hague
Netherlands
Fax: +31 70 3819677

Edwin Brush
International Service for National Agricultural Research
P.O. Box 93375
2509 AJ The Hague
Netherlands
Fax: +31 70 3819677

Derek Byerlee
The World Bank
1818 H. Street, N.W.
Washington, DC 20433
USA
Fax: +1 202 4776391

Joel I. Cohen
International Service for National Agricultural Research
P.O. Box 93375
2509 AJ The Hague
Netherlands
Fax: +31 70 3819677

Stephen Crespi
British Technology Group Ltd.
101 Newington Causeway
SE1 6BU London
United Kingdom
Fax: +44 171 4037586

Biswajit Dhar
Research and Information System for Non-Aligned and Other Developing Countries
Zone IV, 4th floor
India Habitat Centre
Lodhi Road 110 003
New Delhi
India
Fax: +91 11 4628068

Ruben G. Echeverría
Inter-American Development Bank
1300 New York Avenue, N.W.
Washington, DC 20577
USA
Fax: +1 202 6231786

Howard Elliott
International Service for National Agricultural Research
P.O. Box 93375
2509 AJ The Hague
Netherlands
Fax: +31 70 3819677

Thomas Eponou
"Advisor to the Director of Agriculture and Rural Development."
National Office for Technical Studies and Development of Ivory Coast.
08 BP 1471
Abidjan 08
Cote d'Ivoire
Fax: +225-446799

Shenggen Fan
International Food Policy Research Institute
1200 17th Street, N.W.
Washington, DC 20036-3006
USA
Fax: +1 202 4674439

Marian Fuchs-Carsch
Rose Cottage
3 Cherry Tree Farm
Cherry Tree Lane
Hemel Hempstead
Herts HP2 7HS
United Kingdom,

Willem Janssen
International Service for National Agricultural Research
P.O. Box 93375
2509 AJ The Hague
Netherlands
Fax: +31 70 3819677

John McIntire
The World Bank
1818 H. Street, N.W.
Washington, DC 20433
USA
Fax: +1 202 4776391

Harry M. Mule
TIMS Ltd.
Electricity House
11th floor
P.O. Box 49946
Nairobi
Kenya
Fax: +254 2 331068

Philip G. Pardey
International Food Policy Research Institute
1200 17th Street, N.W.
Washington, DC 20036-3006
USA
Fax: +1 202 4674439

Carl E. Pray
Rutgers University
Dept. of Agricultural Economics and Marketing
P.O. Box 231
New Brunswick, NJ 08903-0231
USA
Fax: +1 908 9328887

Johannes Roseboom
International Service for National Agricultural Research
P.O. Box 93375
2509 AJ The Hague
Netherlands
Fax: +31 70 3819677

Steven R. Tabor
International Service for National Agricultural Research
P.O. Box 93375
2509 AJ The Hague
Netherlands
Fax: +31 70 3819677

Helio Tollini
International Service for National Agricultural Research
P.O. Box 93375
2509 AJ The Hague
Netherlands
Fax: +31 70 3819677

Eduardo J. Trigo
Fundación ArgenINTA
Cerviño 3110, 1er piso
1425 Buenos Aires
Argentina
Fax: +54 1 8026101

Acronyms

AAASA	Association for the Advancement of Agricultural Sciences in Africa
AARD	Agency for Agricultural Research and Development (Indonesia)
ADB	Asian Development Bank
ADI	Agricultural Development Institute (South Africa)
AfDB	African Development Bank
ARC	Agricultural Research Council (South Africa)
ARC	Agricultural Research Council (Zimbabwe)
ARI	agricultural research intensity
ART	Agricultural Research Trust (Zimbabwe)
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ATC	Applied Technology Centre (India)
ATS	agricultural technology system
ATSAF	Council for Tropical and Subtropical Agricultural Research (Germany)
AusAID	Australian Agency for International Development
AVRDC	Asian Vegetable Research and Development Center
BADC	Belgian Administration for Development Cooperation
BMZ	Bundesministerium f r Wirtschaftliche Zusammenarbeit und Entwicklung (Germany)
CAFT	Center for Advanced Food Technology (Rutgers University, USA)
CARDI	Caribbean Agricultural Research Institute
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza
CBD	Convention on Biological Diversity
CEMAGREF	Centre Nationale du Machinisme Agricole, du Génie Rural, des Eaux et des For ts (France)
CGIAR	Consultative Group on International Agricultural Research
CIDA	Canadian International Development Agency
CIMMYT	International Maize and Wheat Improvement Center
CIRAD	Centre de Coopération International en Recherche Agronomique pour le Développement (France)
CONDESA	Consorcio para el Desarrollo Sostenible de la Ecoregión Andina
CONICYT	National Council for Scientific and Technological Research (Chile)
CORAF	Conférence des Responsables de la Recherche Agronomique en Afrique
CORPOICA	Corporación Colombiana de Investigación Agropecuaria (Colombia)
CP	concept paper
DAD	Department of Agricultural Development (South Africa)
DAEM	Department of Agricultural Economics and Marketing (South Africa)
DAFS	Directorate of Agricultural Field Services (South Africa)
DANIDA	Danish International Development Agency
DAR	Directorate of Agricultural Research (South Africa)
DATS	Department of Agricultural Technical Services (South Africa)
DCI	Department of Commerce and Industry (Philippines)

DGIS	Directorate General for International Cooperation (Dutch Ministry of Foreign Affairs)
DOA	Department of Agriculture (South Africa)
DRT	Department of Research and Training (Tanzania)
DSE	Deutsche Stiftung f r Internationale Entwicklung (Germany)
EARNET	Eastern African Roots and Tubers Research Network
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuaria (Brazil)
EPC	European Patent Convention
EPHTA	Ecoregional Program for the Humid and Subhumid Tropics of Sub-Saharan Africa
ESDAR	Office for Agricultural Research and Extension of the World Bank
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FHIA	Fundación Hondureña de Investigación Agrícola
FM	financial management
FONDEF	Fund for the Promotion of Scientific and Technological Development (Chile)
FONTAR	Fondo Tecnológico Argentino (Argentina)
FRIM	Forest Research Institute of Malaysia
FTE	full-time equivalent (unit of human resource capacity, especially researchers)
FUNDAGRO	Fundación para el Desarrollo Agropecuario (Ecuador)
FUSAGRI	Fundación Servicio para el Agricultor
GAAPs	generally accepted accounting principles
GATT	General Agreement on Tariffs and Trade
GDP	gross domestic product
GLDP	Grain-Légume Development Project (Ghana)
GTZ	Deutsche Gesellschaft f r Technische Zusammenarbeit (Germany)
HHRRC	Hunan Hybrid Rice Research Center (China)
IARC	international agricultural research center
IBRD	International Bank for Reconstruction and Development (World Bank)
ICA	Colombian Institute for Agricultural Research
ICAR	Indian Council of Agricultural Research
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDA	International Development Association (World Bank)
IDB	Inter-American Development Bank
IDRC	International Development Research Centre (Canada)
IFAD	International Fund for Agricultural Development
IICA	Instituto Interamericano de Cooperación para la Agricultura
IICB	International Institute of Cell Biology (Ukraine)
IITA	International Institute of Tropical Agriculture
ILO	International Labour Office (United Nations)
INIA	national institute for agricultural research (Latin America generally)
INIA	Instituto Nacional de Investigación Agropecuaria (Chile)
INIA	Instituto Nacional de Investigación Agropecuaria (Uruguay)
INIAP	Instituto Nacional Autónomo de Investigaciónes Agropecuarias (Ecuador)
INSAH	Institut du Sahel

INSORMII	International Sorghum and Millet Improvement Network
INTA	Instituto Nacional de Tecnología Agropecuaria (Argentina)
IPR	intellectual property rights
IRPA	Intensification of Research Priority Areas program (Malaysia)
IRR	internal rate of return
IRRI	International Rice Research Institute
ISNAR	International Service for National Agricultural Research
JADF	Jamaica Agricultural Development Foundation
JICA	Japan International Cooperation Agency
KfW	Kreditanstalt f r Wiederaufbau (Germany)
LAC	Latin America and the Caribbean
LDC	less-developed country
MARDI	Malaysian Agricultural Research and Development Institute
MCB	Malaysian Cocoa Board
MTA	material transfer agreement
NALRP	National Agriculture and Livestock Research Project (Tanzania)
NARC	national agricultural research council
NARO	national agricultural research organization
NARO	National Agricultural Research Organisation (Uganda)
NARS	national agricultural research system(s)
NJAES	New Jersey Agricultural Experiment Station (USA)
NJCST	New Jersey Commission on Science and Technology (USA)
NORAD	Norwegian Agency for Development Cooperation
NPV	net present value
NSDO	National Seed Development Organisation (UK)
ODA	Overseas Development Administration (UK)
ODI	Overseas Development Institute (UK)
OECD	Organization for Economic Cooperation and Development
PARC	Pakistan Agricultural Research Council
PBI	Plant Breeding Institute (UK)
PBR	plant breeders rights
PCT	Patent Cooperation Treaty
PORIM	Palm Oil Research Institute of Malaysia
PROCIANDINO	Programa Cooperativo de Investigación y Transferencia de Tecnología para la subregión Andina
PROCICARIBE	Programa Colaborativo de Investigación para el Caribe
PROCISUR	Programa Cooperativo para el Desarrollo Tecnológico Agropecuario del Cono Sur
PROCITROPICOS	Programa Cooperativo de Investigación y Transferencia de Tecnología para los Trópicos Suramericanos
PROCODEPA	Programa Regional Cooperativo de Papa
PVR	plant variety rights
R&D	research and development
RDCs	research and development corporations (Australia)
RFP	request for proposals
RRIM	Rubber Research Institute of Malaysia
SACCAR	South African Centre for Cooperation in Agricultural and Natural Resources Research and Training
SADC	Southern African Development Community
SAES	State Agricultural Experiment Stations (USA)

SAREC	Swedish Agency for Research Cooperation with Developing Countries
SDC	Swiss Development Cooperation
SIDA	Swedish International Development Authority
SPAAR	Special Program for African Agricultural Research (World Bank)
TG&T	technology generating and transfer capacity
TRIPs	Trade-Related Aspects of Intellectual Property Rights
TTA	Tanzania Tea Association
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
UPOV	International Union for the Protection of New Varieties of Plant
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WAFSRN	West African Farming Systems Research Network
WHO	World Health Organization (United Nations)

Part 1 Finance Policy for Agricultural Research

Steven R. Tabor

The policy environment within which research organizations operate sends signals about which types of research should be conducted and defines the structure and organization of the research bodies. It also establishes the level and nature of the resources provided to carry out the research mission. Finance policies for agricultural research strongly influence both the level of the research effort and the degree to which that effort is linked to particular sectoral or scientific goals and objectives.

Policy makers have to take several kinds of decisions about agricultural research finance. At the outset, they must decide how much to commit to the agricultural research effort. Many factors need to be considered. Chapter 1 discusses the ways in which policy makers can assess whether the aggregate funding level is appropriate.

Policy makers also have to pass judgment on how well funding is being used. For public expenditures, such funding would be divided between capital and recurrent outlays, with a large portion of the latter generally being allocated to the wage bill. Chapters 2 and 3 discuss ways in which policies affecting capital and recurrent spending in agricultural research can be crafted to avoid suboptimal use of scarce research funds. Chapter 4 discusses remuneration policies, and in particular, those pay policies that can inspire solid performance from researchers.

But sometimes the task is not to manage new investment or recurrent spending, but to adjust the research effort in a period of diminishing resources. Many research institutes have faced the challenge of operating with less resources than expected. Chapter 5 discusses options for coping with fiscal stress, that is, establishing suitable research financing policies when downsizing is the order of the day.

Donor agencies, too, are involved in supporting agricultural research, and in some countries they provide a significant share of total funding. Making the best use of aid funds is a particular challenge for the national agricultural research systems. Chapter 6 discusses policies that will ensure that aid funds for agricultural research are used effectively.

The way in which the various entities comprising an agricultural research system are organized and structured gives them access to funds and allows them to operate in very different funding environments. Policy makers need to be aware that decisions on structure and organization go hand in hand with decisions on funding options for agricultural research. This is the subject of chapter 7.

Chapter 1
Towards an Appropriate Level of Agricultural Research Finance

Steven R. Tabor

Introduction

Agricultural research faces growing demands for appropriate solutions to problems of growth, poverty reduction, environmental sustainability, and food security. Technological gaps between agricultural production in the South and in the North are widening. As globalization proceeds, low-income countries will need to speed up technological progress simply to remain competitive on world markets. Adverse environmental costs of agricultural development must also be reduced, implying the need for a new generation of technologies that are both more profitable and more ecologically sustainable. And in many parts of the world, poverty and food insecurity are still the bitter reality for millions of small farm households (Dollar 1993, Pinstrup Andersen 1994).

Agricultural research faces these challenges in a period of waning public-sector support for agriculture and for agricultural research and development (R&D). Many governments have little room to increase public expenditure commitments and, indeed, are busy narrowing the role of the public sector. Donor interest in agriculture (Von Braun et al. 1993) and in agricultural research (Brown 1994, Echeverría 1995, Hardin 1994, FAO 1994) is waning. Can agricultural research, hitherto largely a publicly funded activity in the developing world, meet these growing demands in this new funding environment? While there may be no need for alarm, policy makers should not ignore this question.

But how can a policy maker judge whether the level of agricultural research finance is adequate? The answer is complicated by the difficulty in predicting payoffs to risky scientific activity and by the fact that the funding decision for agricultural research transcends institutional, temporal, and national borders. It is the sum of many individual institutional funding outcomes that determines the agricultural research expenditures in a country at a given point in time. This is true in both the public and private sectors, international agricultural research centers, universities, national research organizations, agribusiness, regional bodies, nongovernmental organizations, and even farmers' fields. The funding decision may well include a large "overseas" element. The greater the importance of international technology and information inflows to the generation of a nation's agricultural technology, the greater the importance of international research expenditures (Folster 1995, Jaffe 1988). Hence, the research financing related to a research output in a given country reflects both the decentralized funding decisions of national institutions and the funding decisions of institutions that supply technology and information flows to that country.

Agricultural research activities financed in a particular country are analogous to a link in a chain that has both temporal and geographical dimensions (Howe and McFetridge 1976). As part of a larger, dynamic system, the extent to which funding is adequate will be influenced by

- *the role of research:* the importance of productivity improvement compared with other sources of agricultural growth;
- *burden-sharing:* technology that should be financed and generated domestically, versus that which can be identified and imported from supranational sources;
- *past funding decisions:* the profound influence of earlier research on current capacity to generate new knowledge;
- *ex ante expectations:* the extent to which higher spending on agricultural research can reasonably be expected to have a positive payoff, i.e., contribute significantly to the achievement of goals and objectives set for the agricultural sector.

These conditions will change over time and differ from one country to another. This makes the application of hard and fast agricultural research funding rules difficult, if not impossible. Reaching decisions on the appropriate role of research, the degree to which national effort is required, the extent to which existing capacity can be marshaled to meet national objectives, and the probability that such efforts will pay off is a matter of *judgment.* Unfortunately, those who frame research policies often lack the specialized expertise needed to reach decisions on such matters.

While a country's scientists may be in the best position to advise on these matters, they clearly will have a vested interest in maximizing the flow of resources to their own work. In practice, this means the research financing decision must be made in a highly information-imperfect environment[1] marked by uncertainty (De Janvry and Dethier 1985). In this situation, there is no single optimal level of research financing; rather, there is a wide range within which

---

1. Governments may have to rely on external experts (i.e., ones outside the research system) to validate or correct information provided by researchers.

policy makers could conclude that agricultural research funding is satisfactory (Roberts and Weitzman 1981).[2]

This chapter examines several issues involved in assessing the adequacy of agricultural research financing in a given developing country. The approach relies heavily on standard tools of economic analysis. This is both its strength and its weakness. The advantage of an "economistic" approach is that agricultural research activities are treated as a financial investment in which a certain financial return is anticipated. The disadvantage is that if agricultural research is financed for other motives (such as advancement of knowledge, prestige, or populist politics), then economic arguments may not be very persuasive in the political context in which funding decisions are actually made.

The rest of this chapter is divided into five sections. Section 2 discusses the economic role of agricultural research and reviews the main arguments for public-sector support of such research. Section 3 examines issues related to assessing the costs and returns of agricultural research. Section 4 discusses the "under-investment hypothesis," in light of recent estimates of the rate of return to agricultural research in developing countries. Section 5 turns to the use of snapshot indicators of research spending and the extent to which these are a useful guide to funding adequacy. Section 6 concludes the chapter with a discussion of indirect decision rules that could be used, in a form of iterative learning process, to close the gap between actual and suitable levels of agricultural research expenditures.

The Economic Role of Agricultural Research

Agricultural research uses real resources and, if successful, generates private and public benefits. As such, it can be considered a form of economic investment. Expenditures on agricultural research are made with the expectation that they will pay returns in the future (Mansfield 1982). Figure 1 illustrates, in stylized fashion, the mechanisms by which agricultural research expenditures are translated into economic returns.

Agricultural research expenditures, in the form of training, station development, and other capital works, are intended to build a country's institutional capacity to undertake research. Operational spending on institutions uses that capacity to generate new knowledge and facilitate the inflow of new technologies. The combination of existing knowledge, new domestically generated knowledge, and technology inflows produces a pool of available agricultural technology. Only a portion of this technology is likely to be suitable or adaptable immediately. However, through various mechanisms of diffusion, the pool can be tapped to stimulate technological change in agriculture. This results in higher agricultural factor productivity or, in the case of agricultural resource management and policy, in the creation or enhancement of an enabling

[2] Roberts and Weitzman (1981) discuss the possible use of sequential decision rules to reach an optimal level of research spending when information is incomplete or subject to a priori bias.

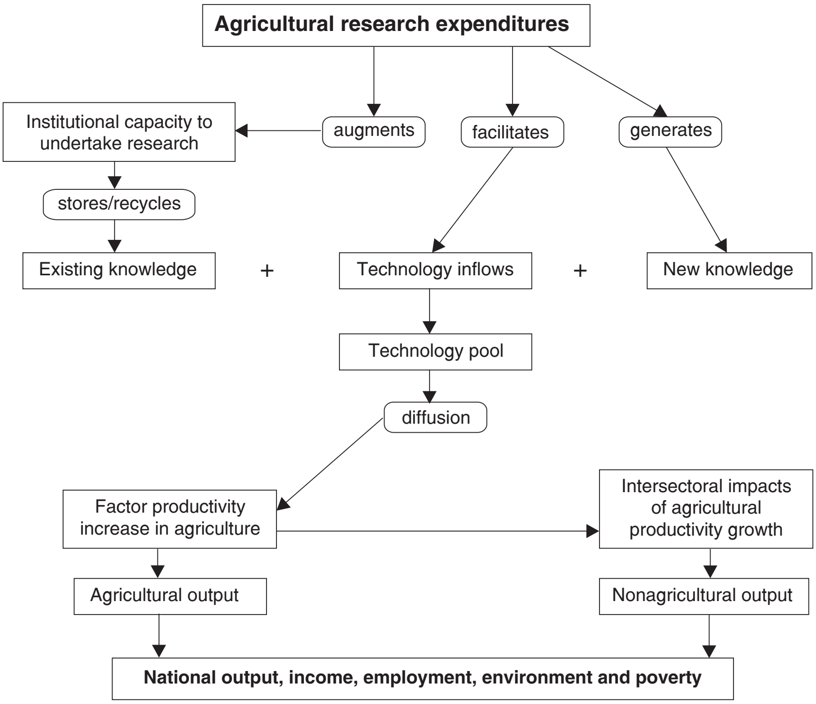


Figure 1. Agricultural research expenditures

environment. An improvement in factor productivity means that either more is produced with the same level of resources, or, in the case of cost-saving innovations, that the same amount is produced with fewer resources (Kim 1993, Alston and Pardey 1996).

Higher agricultural output, or the same output at a lower cost, will have a direct impact on agricultural incomes, trade, and employment. To the extent that the demand for the agricultural products in question is price inelastic, prices will fall and consumers will benefit (Alston and Pardey 1996).

The direct benefits of higher agricultural output on consumer welfare may be significant. Following Engel's Law, the share of income allocated to foodstuffs falls as incomes rise. There is ample evidence that aggregate elasticities for foodstuffs and agricultural raw materials tend to become inelastic by middle- income levels in developing countries. When demand is highly inelastic—as would be expected, for example, for a nontraded foodstuff in a middle-income country—then prices would fall as output rises (Huffman and Evenson 1993). Accordingly, consumers would be the primary beneficiaries of higher agricultural productivity through lower product prices. Although farmers may be the main "target group" for agricultural research, depending on market conditions, consumers may well be the main direct beneficiaries of technological innovation. All too often, agricultural research financiers (and leaders of research systems) presume that farmers are the main beneficiaries of agricultural research. In an environment of inelastic agricultural demand, this is unlikely to be the case.[3]

Where agricultural marketing systems are noncompetitive and noncontestable, the direct benefits of agricultural productivity increases are likely to be captured within the marketing chain. Higher incomes resulting from an increase in agricultural output would accrue to traders, processors, or other marketing intermediaries. Again, financiers of agricultural research, particularly in countries with poorly developed market infrastructure, should be aware that marketing intermediaries may be major beneficiaries of (and possibly a hindrance to) technological innovation in agriculture (Dasgupta and Stiglitz 1980).

The distribution of benefits from agricultural research can change significantly depending on a country's external trade regime. In a developing economy closed to agricultural trade, demand for agricultural products may become highly inelastic when the "small" internal market is exhausted. When a country opens up the agricultural sector to foreign trade, demand becomes more elastic as agriculture becomes essentially a "price-taker" on global markets. Opening an economy to foreign trade can also improve the competitiveness of agricultural marketing systems, in that domestic traders must then compete with importers and exporters. Changes in a developing country's agricultural trade regime can, in fact, have a more potent effect on the distribution of the direct benefits of agricultural research than would result from, for example, better targeting of agricultural research outlays (Voon 1994, Sexton and Sexton 1996). For large exporters trading in commodities that face inelastic demand, the exporting countries may actually lose from agricultural research, as the output of that research is captured by importing or competing countries, resulting in a decline in the terms of trade.

While the direct effects of agricultural research on production and consumer welfare are important, the indirect, intersectoral effects of agricultural productivity growth may be more important still. For example, higher agricultural output will stimulate employment in agricultural processing, distribution, packaging, retailing, and other trade-related services. Higher agricultural incomes boost demand for domestically produced nonagricultural goods. Lower agricultural prices reduce real wage costs in the nonagricultural sectors. Lower wage costs, in turn, stimulate nonagricultural employment and output. Reduced costs in the nonagricultural sectors combine with higher agricultural incomes to stimulate savings and investment throughout the economy. Empirical studies have found that the indirect, nonagricultural effects of higher agricultural output are very large, particularly in low-income countries. In Kenya and India, for example, there is evidence that the indirect economic effect of higher agricultural output during the 1970s and 1980s was well in excess of the direct economic effect. This relationship is likely to hold in countries in which: i) the agricultural sector is large relative to the nonagricultural produc-

3. In an export-oriented, upper-income setting, the reverse may be the case. For an interesting case of farmer-financed research in Israel, see Gelp and Kislev (1982).

tive sectors; ii) domestic agricultural output constitutes a significant share in nonagricultural wages; and iii) where the agricultural and nonagricultural sectors are closely integrated (Haggblade and Hazell 1989).

Agricultural research can also have important effects on a country's macroeconomic balances. In many low-income countries, food prices account for much of the movement in consumer prices and food imports have a significant share of total imports. Food shortages can trigger an increase in inflation and add to balance-of-payments pressures. In countries that have an unhealthy external payments position to begin with, agricultural shortages may trigger a spiral of higher food imports, exchange rate devaluation, imported inflation, and compression of nonagricultural imports.

Conversely, high rates of agricultural growth can ease pressure on domestic food prices, increase export earnings, and contribute to a healthier balance of payments. On the fiscal side, taxes on agricultural trade are often an important source of domestic revenue in low-income countries, mainly because there is little other productive activity to tax. In such circumstances, high agricultural growth rates will augment government revenues, broaden the tax base (by contributing to growth in nonagricultural activity), and reduce deficit-spending pressures. Agricultural research makes an important contribution to the overall investment environment in the country by contributing to sound macro- economic balances (Tabor 1995).

Agricultural research can also have major nonmarket outcomes, especially for the environment and poverty levels. In most countries, agriculture is the single largest user-cum-custodian of natural resources. Technological innovation in agriculture can have a mix of both positive and negative effects on the environment. Groundwater pollution, soil erosion, and loss of biodiversity are some of the adverse environmental effects of agricultural intensification. But intensification has also reduced pressure to expand farming into fragile or environmentally vulnerable areas. Accordingly, technological innovation in agriculture has a *net* (and not always positive) effect on the implicit value of a nation's natural resources. And while this net effect may not be valued in a market, it is likely to be of considerable economic significance.

Agricultural research can have a powerful effect on poverty alleviation, primarily by raising labor productivity. The poor have few assets other than their labor. Technological innovation that raises the labor productivity of the poor, both in and outside the agricultural sector, also raises incomes and improves living standards for the most vulnerable segments of a country's population. Poverty alleviation, in turn, can improve the distribution of income, and lead to higher rates of balanced growth and development. Of course, technological innovation may also displace certain groups of agricultural workers. So again, there is a net effect on poverty alleviation.

In summary, looking at agricultural research investment as a *financial* activity, we can expect several direct and indirect *financial* payoffs:

- the direct effects of higher agricultural output (or lower costs) on producers and consumers;

- the indirect intersectoral effects on the nonagricultural segments of the economy;
- the effects on macroeconomic balances and the overall investment environment;
- the effects on key nonmarket determinants of long-term economic growth and development, such as environmental sustainability and poverty alleviation.

Governments and donors are the main financiers of agricultural research in developing countries. One reason, as noted above, is that the expected benefits of agricultural research extend throughout the economy, particularly where intersectoral, macroeconomic and nonmarket effects of innovation are large. In this case, public-sector funding of agricultural research is, in effect, a way to match the costs and the benefits of the research.

In practice, much of the agricultural research conducted in developing countries displays the essential traits of a "pure public good." First, it is specifically intended to generate external benefits. In other words, it is the farm community, consumers, industry, government, and other institutions that benefit when agricultural productivity rises; the benefits accruing to the generators of agricultural research findings are typically a minute fraction of the total social returns to research. Second, consumption of the research outputs is nonrival in the sense that the use of newly created knowledge by one end user does not diminish its availability to others. Third, given the weak legal protection of intellectual property rights in many developing nations, it would be costly to stop certain potential users from gaining access to the products of the research service. This inability to exclude free-riders, or to stop those from using research without bearing the costs, explains, to a large part, why incentives for private provision of agricultural research services in developing nations are limited (Thirtle 1986).[4]

However, that low level does not mean there isn't scope for increased private-sector research, or that the contribution of the private sector to technological innovation is insignificant (Lichtenberg 1987, USAID 1995). First, the private sector tends to concentrate its agricultural research efforts on areas where results can be privately appropriated. In developing countries, much of the private sector's research effort has gone into hybrid seed development, export-oriented products, plantation crops, and off-farm processing of agricultural products. Second, the private sector in developing nations often plays an important role in identifying, importing, and diffusing technological innovations that are embodied in capital goods, such as improved agrochemicals and farm machinery. And third, public-private partnerships in the financing and execution of research activities are growing in importance, particularly in Latin America, where a number of competitive research funding mechanisms have been introduced (Umali 1991).

---

[4] Byerlee (1994) notes that, even in developing countries with sound intellectual property laws, enforcement costs to protect agricultural innovations will likely be prohibitive.

The appropriate level of private-sector expenditure on agricultural research is defined by private expectations of the payoffs from such investments. Where private costs of capital are high, where research is deemed to be high-risk, and where there are ample alternative opportunities for private investment, the perceived ex ante private benefits from agricultural research have to be very high before the private sector will make a significant funding contribution (Romano 1991, Umali 1991).[5]

The public-good nature of much agricultural research in the developing world, combined with the limited role of the private sector, helps explain why governments absorb the great bulk of the cost of agricultural research. That research benefits are likely to be more indirect than direct in low-income countries is another reason for governments to play a major role in research funding. But while there may be a strong economic rationale for government funding, how big a role should this be?

The Costs and Returns to Agricultural Research

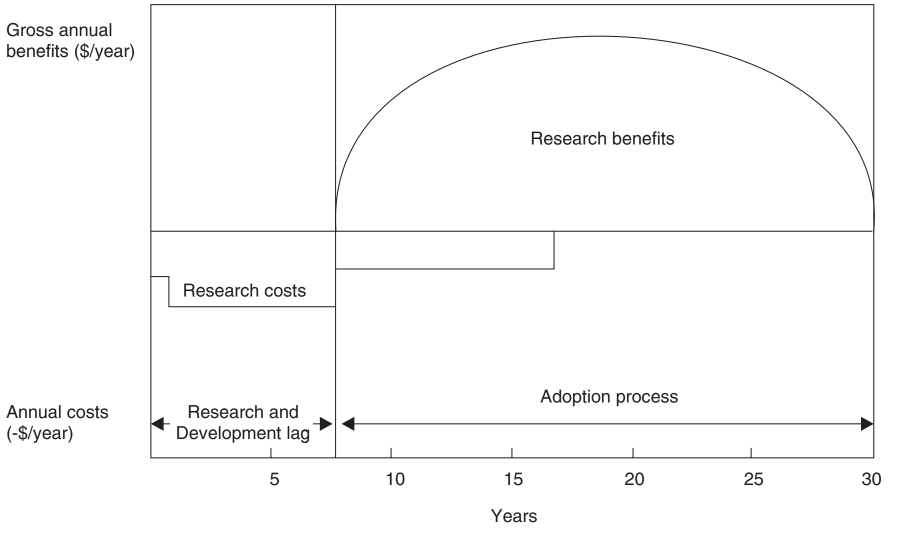
In theory, government should invest in agricultural research up to the point where the expected returns from a marginal investment in additional research are equivalent to the long-run cost of capital to the public sector. The "optimal level" of public expenditure on agricultural research hinges on the government's ex ante view of the likely costs and returns of such expenditures and on a comparison of that return to the expected cost of capital to the public sector (Knutson and Tweeten 1979, White and Havlicek 1982).[6]

Figure 2 is a stylized example of the flow of costs and returns to a hypothetical agricultural research investment (Alston, Chalfant, and Pardey 1995). For any research activity, there is be a time lag during which costs are incurred but no benefits are produced. In a breeding trial for field crops, for example, it may be four to six years before a new variety is produced, and another two to three years before it is tested to meet field conditions. After seven or eight years, the variety could be introduced to the farm community. Early adapters would then begin to experience the benefits of the improved technology. Over the next several years, the benefits would increase as the technology is diffused to a larger share of producers, and as the indirect effects of technological innovation percolate through the economy. For a few years, R&D costs may continue

---

5. The private sector may also be "crowded out" of the market for agricultural research investment by government outlays on investment activities (for example, agricultural machinery) that would otherwise be undertaken privately (Benyon 1995). The private sector may also face barriers-to-entry in agricultural research. The initial costs of establishing research facilities and training staff, for example, may exceed the funding capacity of any individual enterprise.

6. The prevailing cost of capital to government may or may not reflect its social opportunity cost. Government over-expenditure may occur when the public sector has preferred access to low-cost sources of funding or does not perceive the costs associated with crowding out private initiative (Shah 1994, Pradhan 1995).



Source: Alston, Norton, and Pardey (1995)

Figure 2. Stylized flow of benefits and costs from a hypothetical research investment

to be incurred as further testing and field modification are carried out, progress is monitored and evaluated, and extension and outreach activities proceed. Eventually, the variety is likely to become economically obsolete, either because it no longer exhibits the vigor and response it once did or because it has been superseded by another improved variety. As economic obsolescence sets in, the benefits from a research activity begin to decline (Ravenscraft and Scherer 1982).

With a known, or forecast, flow of costs (Ci) and benefits (Bi) from a particular research activity, and the forecast cost of capital to government over time (Ii), the net present value (NPV) of the research activity can be computed as:

$$NPV = \Sigma\,(Bi - Ci)/\,(1 + Ii)^t \qquad (1)$$

If the net present value is positive, then the rate of return on the agricultural research activity would exceed the public sector's expected cost of capital. If the net present value is negative, as could well occur in countries with a high cost of capital to government (or long R&D lags), then the rate of return would be less than the public sector's expected cost of capital. The actual internal rate of return of an agricultural investment can be computed analogously by setting the NPV to zero and solving equation 1 for the average interest rate (Ii) over the total period.

There may be circumstances in which ex ante returns are misleading. If the agricultural sector is protected, then producers may have a greater latent demand to adopt new technology than would be the case in a more neutral agricultural policy setting (Anderson 1995 and Voon 1994). The nature of agricultural research, as a lumpy and often irreversible investment which exhibits strong economies of time, scale, and scope, implies that average and marginal returns to additional spending can be very different (Fisher and Temin 1973). This becomes clearer when one imagines investment not in the sense of a series of small, continuous activities, but in large lumpy investments in staff or facilities of one kind or another.

Figure 3 below provides a hypothetical trajectory of the average rate of return to research in an agricultural research system, by stage of institutional development. When there is no institutional capacity in place to conduct research or to capture research findings, the rate of return to agricultural research is, of course, zero. During the early stages of development (the "start-up phase" in Figure 3), the rates of return to agricultural research investment are likely to be negative. Most costs during this phase are associated with setting up facilities, stations, and equipment, and in training an initial cadre of scientists and support staff. Very little actual research is done as the initial research capacity is being created.

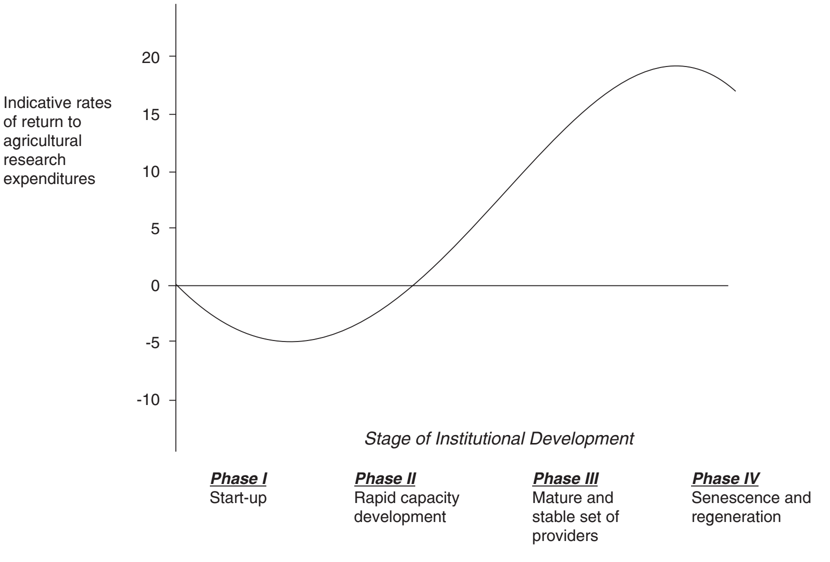


Figure 3. Indicative rates of return to agricultural research by stages of institutional development

In the second stage, the research system is likely to experience rapid capacity development. More scientists are trained, staff are added to new and existing institutions, and many research projects are conducted. It is during this second phase that the rate of return to agricultural research expenditures can be expected to move into positive territory. At a certain point, agricultural research capacity in a particular country stabilizes (as happened in many countries in Latin America during the 1980s), and the research system can be classified as "mature". In a mature system, rates of return to research expenditures tend to reach their peak for two reasons. First, research expenditures in such systems are allocated primarily to utilization of research capacity rather than its expansion. Second, an institutional process of learning-through-doing should have yielded what are described as time-economies, or improvements in organizational ability to undertake a given set of tasks.[7]

The rate of return to agricultural research is unlikely to stay at its peak indefinitely in a mature system. It may fall because the agricultural research challenge has become more difficult,[8] because the "technology of research itself" has changed (e.g., the growing role of biotechnology), or because institutional structure, management, and organization have become rigid.

That the expected trajectory of rates of return to agricultural research varies over time provides profound lessons for policy makers. As with many complex institutions, an agricultural research system is an investment with a long gestation period. Until a "critical" core of researchers and research facilities has been established, returns to research expenditures are negative. Thereafter, as both research capacity and its utilization increase, returns rise. But, unless adequate funding policies are in place, rates of return to agricultural research expenditures could continue to remain negative. Research spending could continue to be concentrated on capacity expansion, with inadequate resources devoted to using the growing research capacity. This has been cited, for example, as a problem in several research systems of sub-Saharan Africa. Another important policy lesson is that returns to research investments, in the aggregate, have to be evaluated over a long period of time. This is because of the R&D lags typical of any set of experiments (see Figure 2), and, even more important, because of the lags in returns to investment in lumpy research systems that must establish and expand capacity before putting it to use.

While the shape of the "returns to research system investment" curve (see Figure 3) is most likely sigmoidal, the absolute magnitude of expected returns at any point on the curve depends on a host of factors, both external and internal to the research service. Among the main external factors are the clarity of policy signals sent to the research service, the level of complementary investments in rural development, and the amenability of prevailing agricultural challenges to research-based solutions. The extent to which research is focused on priorities and how well scientific efforts are managed and rewarded are among the most important determinants of the internal or organizational efficiency of the research effort.

The absolute magnitude and timing of government funding, as well as the method of disbursement, directly affect returns to agricultural research (Bre-

---

7. There has been an intensive debate about the productivity slowdown in OECD nations and its links to the structure and operation of R&D enterprises (Lichtenberg 1992; Englander, Evenson, and Hanazaki 1988; and US Congress 1995).

8. Byerlee (1994) argues that this is the case in Asian agriculture due to the already high level of adoption of modern grain varieties in these countries.

dahl, Bryant, and Ruttan 1980). If funding levels are chronically insufficient, a research system may become stuck in the start-up phase, never achieving positive rates of return. Unstable funding reduces returns both because long-term research projects are interrupted and because the expansion and use of research system capacity are adversely affected. Where wages and salaries account for a large share of total research system expenditures, funding volatility may prompt research leaders to compress all other recurrent costs, reducing both capacity utilization and returns to research expenditures.[9] Finally, if public expenditures on agriculture research are not disbursed in an effective and efficient fashion—due to inadequate oversight, perverse incentives systems, weak management or other organizational failures—expected returns will fall (Byerlee 1994, Donovan 1995).

It is also worth noting that the financial evolution of a research system along such a trajectory is hardly unidirectional. There are examples of developing-country research systems that have experienced profound funding shocks, lost many professional staff, or suffered a collapse in morale. These systems have quickly moved from an advanced to a near-start-up level of institutional capacity. Sustaining funding support long enough to achieve positive returns from agricultural research is a major challenge for many developing countries. But, as with other lumpy investments, governments unable to bring their investment in research to the point where it pays returns probably shouldn't be making the investment in the first place.

Evidence and Causes of Underinvestment

In practice, what has been the apparent "economic return" to investments in agricultural research? Many empirical studies have tried to answer this question. There are two commonly used approaches to measuring such returns. In the first, an estimate of multi- or partial-factor productivity change is computed and related to lagged spending on agricultural research, extension, education, and other factors that may have induced the apparent productivity change. In the second, "meta-production" approach, agricultural output is related directly to research spending, factor prices, and other factors that may have accounted for a shift in production over time (Griliches 1964 and 1979, Evenson and Pray 1991).

Both of these approaches are used to measure the direct "agricultural" benefits of agricultural research and as such present only a very incomplete measure of the total impact of an agricultural research investment. As noted above, benefits to consumers, as well as intersectoral, macroeconomic, and nonmarket impacts, are likely to be large, particularly in low- and middle-income nations.

---

9. For a further discussion of recurrent cost funding and management problems, see Chapters 3, 4, and 5.

Almost all empirical studies of technology impact—those of agricultural research being no exception—suffer from difficult conceptual, data, and measurement problems (Griliches 1994), among them the following:

- The underlying conceptual rationale for such studies is that technological innovation can be measured as a form of technology residual, after other factors that influence agricultural productivity have been taken into account. Other authors have argued that the rate and direction of productivity change is endogenously determined in an economy, and therefore must be captured by qualitative change in conventional factors of production and more fully specified systems of factor productivity improvement (Romer 1990, Manikow et al. 1992).
- Such studies typically exclude hard-to-measure determinants of technological innovation (and competitiveness). Examples are the costs of communicating research findings to users, the state of law and order, the degree to which agricultural property rights are defined, the incentives and enabling environment for agriculture, the development of rural economic and social infrastructure, and the more general development of market infrastructure. Excluding these factors results in a far greater share of the benefits of technological innovation being attributed to agricultural research than should logically be the case.
- Distinguishing the effects of agricultural research from other forms of capital accumulation may be impossible if such investments are embodied in improvements in the quality of the labor force (as may happen when recommendations for improving farm management are adopted) or in the quality of capital goods (e.g., more productive agricultural inputs).
- Few studies incorporate nonmarket effects. If, for example, higher agricultural output comes at the expense of the depletion of nonrenewable resources, the returns to research may be seriously overestimated.
- Most studies measure only the impact of an "agricultural research success" on the direct returns to growth in a particular commodity. Due to the possibility of factor and product substitution, the aggregate agricultural effects of progress registered on any single commodity are likely to be far less than partial estimates would suggest. Failure to take into consideration these factor and substitution effects, as well as the costs of all research activities, introduces an upward bias in rate-of-return estimates.

In practice, rate-of-return studies of agricultural research investments typically compare a relatively small financial outlay (agricultural research investments are inevitably a small share of public expenditures) with a much larger net income stream. Studies are usually made of clear "technology winners" and are often drawn from production progress in well-endowed (often irrigated) areas. Little can be inferred about the returns to the greater part of the research that was not focused on such winning technologies or regions. Furthermore, even in these cases, much of the analytical problem lies in trying to distinguish that part of the income stream attributable to a research-based innovation from that part stimulated by other factors, relatively few of which can be easily measured.

While some of the factors listed above tend to produce overestimates of rates of return to agricultural research, the exclusion of the nonagricultural benefits (consumer, intersectoral, macroeconomic, and nonmarket) of technological change in conventional rate-of-return studies introduces a serious bias in the other direction. The important lesson is that, even with careful measurement, empirical estimates of rates of return to agricultural research are likely subject to a wide margin of error.

Despite their limitations, the majority of studies demonstrate extremely high ex post rates of return to agricultural research. Evenson and Rosegrant (1995) found high rates of return to agricultural research in more than 60 ex post impact studies of agricultural research conducted in Asia. Rates of return in excess of 50 to 60 percent have been identified for investments in rice and wheat research in developing countries (Hayami and Ruttan 1985; Pray 1991 and Pardey et al. 1991). In his review of several hundred agricultural research rate-of-return studies, Echeverría (1991) has shown that the returns to agricultural research in developing countries can be very high indeed. In many cases, reported rates exceed 60 to 70 per cent, and are identified for major commodities in almost all parts of the developing world (see Table 1.)

Table 1. Rates of Return to Agricultural Research

Commodity	Country	Rate of return to research	Author
Maize	Mexico	78-91%	Ruvalcaba (1986)
Rice	Indonesia	60-65%	Pardey (1993)
Rice	India	65%	Evenson (1990)
Wheat	Pakistan	58%	Nagy (1983)
Soybeans	Brazil	46-69%	Ayres (1985)
Sugarcane	Philippines	51-71%	Librero (1987)
Potatoes	Peru	22-42%	Norton (1987)
Maize	South America	191%	Evenson (1989)
Cowpeas	Senegal	60-80%	Schwartz (1989)

Note: For discussion of the concept and significance of rates of return to agricultural research, see Pardey et al. (1991) and R.G. Echeverría (1991).

That reported rates of return are so high, relative to likely capital costs to government, is used as evidence for possible *underinvestment* in agricultural research (de Janvry and Dethier 1985). Many reasons have been advanced for public-sector underinvestment in agricultural research, including

- urban bias;

- weak political constituencies to lobby either for agricultural services or for scientific programs;
- short political cycles which give greater weight to activities with short-term payoffs than to long-term investments;
- the wide distribution of relatively small returns among consumers, industrial groups and other groups, none of whom may perceive that the benefits of agricultural research are large enough to lobby for;
- economic crises which trigger measures aimed at enhancing the short-term impact of public spending;
- a lack of awareness among policy makers of the likely long-term payoffs from agricultural research investments;
- limited absorptive capacity in developing country agricultural research systems, due to an insufficient supply of trained staff and perceived weak management systems;
- the limited ability of agricultural research institutions to articulate and document the range of probable returns associated with agricultural research investments.

While many of these are plausible reasons for underinvestment in agricultural research, high ex post rates of return do not necessarily imply underinvestment in agricultural research. First, agricultural research spending levels are based on ex ante judgments. Actual outcomes may simply have exceeded expectations. Second, the reported values are measures of average rates of return. Returns at the margin may be very different from average returns. Third, agricultural research investments may be perceived to be riskier than other investments, and therefore the expected value of the research investment should be discounted for this perceived risk of failure. And fourth, agricultural research investments are long-gestating. In countries with large numbers of poor people, a premium may have to be attached to those investments that generate payoffs more quickly (Alston and Pardey 1996).

Finally, even if there clearly is underinvestment in agricultural research, and ample reason to believe that additional investment will pay a high marginal return, it is not necessarily appropriate in a world of limited resources to invest more in the agricultural research system. Many factors determine the competitiveness of a particular sector. If other factors, outside R&D, are more seriously "binding constraints" on enhancing agricultural competitiveness, then relieving these constraints will have a higher overall development payoff (Garelli, 1996). In other words, agricultural research must not only demonstrate that it is a good investment, but that it is a more valuable investment than others aimed at achieving similar goals.[10] Almost paradoxically, this implies that if the agri-

[10]. The IMD business institute publishes an annual index of competitiveness for 50 of the world's largest countries. They define competitiveness as a weighted mix of a number of factors, including science and technology capacity, but also domestic economic strength, infrastructure, internationalization, management, quality of government, finance, and the labor force (Garelli 1996). In agriculture, many of these same factors would determine the propensity for growth and technological innovation. While the differ-

cultural R&D system is performing well, but other complementary institutions are not, then it may be economically more advantageous to "fix" these other institutions than to expand support for agricultural research.

Snapshot Indicators

Snapshot indicators, or summary measures of agricultural research spending, are often used to judge the adequacy of a country's commitment to agricultural research. The most commonly used snapshot indicator is the agricultural research intensity (ARI) ratio, which is expenditures on agricultural research expressed as a percentage of agricultural gross domestic product (Agricultural GDP).

Advocates of increased agricultural research spending point to the fact that middle- and upper-income countries spend, on average, close to 2 percent of agricultural GDP on agricultural research, while low-income developing nations tend to spend a much smaller share. The World Bank, for example, has argued that 2 percent of agricultural GDP is an appropriate funding target for all developing countries (World Bank 1981, SPAAR 1996). But is two percent or even one percent a standard that developing countries should strive to meet?

While the average middle- to upper-income nations do spend about 2 percent, many of the upper-income OECD nations spend far less than this (Alston and Pardey 1995; Irvine, Martine, and Isard 1990). It is also true that the agricultural sector in the upper-income OECD nations is very small, and therefore the fiscal burden of agricultural research is trivial. But that is not so for developing countries. Furthermore, countries as diverse as Brazil, China, Indonesia, India, and Mexico have experienced prolonged periods of rapid agricultural growth and technological transformation with agricultural research funding levels well below half a percent of agricultural GDP (Evenson and Pray 1991, Byerlee and Pingali 1995, Pardey and Roseboom 1989).

As a spending indicator, the ARI ratio is misleading in at least four respects, and its use in spending advocacy or funding comparisons should be discouraged:

- The use of agricultural GDP as a funding denominator creates the impression that value-added in agriculture captures the benefits or impacts of agricultural research. As noted above, agricultural research typically effects changes in agricultural productivity, not value-added, and its benefits extend well beyond that of increased value-added in the agricultural sector.
- In countries undergoing rapid structural change, the measure will be more sensitive to the change in agriculture's contribution to economic

ent factors determining competitiveness can substitute for another to a certain extent, there are clearly limits to this, and it is often the binding constraint (or the factor that most inhibits competition) which drags down the returns to all forms of investment.

output than to the government's funding commitment to agricultural research.

- The magnitude of agricultural GDP is highly sensitive to a country's agricultural policy regime. Where policy discriminates against agriculture, through highly overvalued exchange rates for example, agricultural GDP would be far lower than it would be in a more policy-neutral environment. The more adverse the agricultural policy environment, the lower is agricultural GDP. Hence, what the ARI ratio may reflect is not strong support for agricultural research or technological transformation of agriculture, but an adverse policy environment for agriculture as a whole.
- So long as the financial inputs of donors and national agricultural research systems are aggregated in the production of ARI figures, they will have little meaning to policy makers interested in sustainable development, who spend from the discretionary resources available to government, not from the value-added generated by a particular sector.

The ARI ratio, then, has certain decifiencies as an indicator of funding adequacy. However, the fact that it has been codified into a "rule of thumb" by a major financier of developing-country agricultural research suggests that there is a need for benchmarks against which funding standards can be measured.

In searching for such benchmarks, it should be noted that no single snapshot indicator is perfect. But if such tools are to be used, they should relate expenditures either to the impact domain of the activity or to the predominant funding base. The impact domain for agricultural research extends beyond agriculture, especially when intersectoral, macroeconomic, and nonmarket effects are large, and can perhaps be best approximated by national income, or GDP. As for the funding base for agricultural research, in developing countries it is predominantly the government budget. How much a government can afford to spend on agricultural research is limited by the resources at its disposal at any point in time. Total public expenditures (and net lending to the state) provide a proxy measure of this (Pradahn 1995, Premchand 1993). Table 2 below presents two recent "snapshot" indicators for research spending.

According to these measures, funding support for agricultural research varies widely among regions. As a share of GDP allocated to agricultural research, Africa's spending is almost three times greater than Asia's, and Asia's is a little more than double Latin America's. While there is a high degree of country-variability around the regional means, the big differences between regions point to three things. First, regional standards may be more appropriate than global standards for the purposes of comparison. Second, there are undoubtedly economies of scale and scope that explain part of the expenditure differences. And third, relative to what it can afford, Africa is making a relatively large contribution to agricultural research (Ndiritu 1994).

Table 2. Snapshot Indicators of Agricultural Research Expenditures

Region/ country (year)	Share of GDP to agricultural research (%)	Share of public expenditure to agricultural research (%)	Region/ country (year)	Share of GDP to agricultural research (%)	Share of public expenditure to agricultural research (%)
Asia	**.11**	**.60**	**Africa (1991)**	**.3**	**.7**
Bangladesh (**92**)	.10	.66	Botswana	.2	.4
China (**93**)	.09	.54	Burkina Faso	.3	1.6
India (**90**)	.15	.66	Côte d'Ivoire	.3	1.0
Indonesia (**91**)	.06	.29	Ethiopia	.3	.8
Malaysia (**92**)	.16	.57	Ghana	.3	1.4
Pakistan (**92**)	.11	.41	Kenya	.5	1.6
Sri Lanka (**92**)	.08	.29	Lesotho	.1	.2
Thailand (**93**)	.17	1.1	Madagascar	.2	1.4
			Malawi	.6	2.6
Latin America (1992-1993)	**.05**	**.23**	Mauritius	.2	.9
Argentina	.05	.23	Niger	.2	1.3
Brazil	.09	.29	Nigeria	.1	.2
Bolivia	.02	.13	Rwanda	.2	1.1
Colombia	.04	.17	Senegal	.3	1.5
Ecuador	.03	.21	South Africa	.1	.5
El Salvador	.02	.14	Sudan	.1	.4
Guatemala	.04	.31	Swaziland	.3	.8
Mexico	.03	.12	Tanzania	na	na
Panama	.08	.30	Togo	.4	1.5
Paraguay	.05	.35	Zambia	1.5	3.0
Peru	.10	.81	Zimbabwe	.4	1.0
Uruguay	.11	.39			
Venezuela	.03	.14			

Source: See Chapters 14, 15, and 16. Additional calculations use World Bank GDP and Public Expenditure estimates.

When we look at agricultural research's share of public expenditures, the picture is somewhat different. Both Asia and Africa spend about the same (0.7 and 0.6 percent), while the figure for Latin America is about a third of that. This may reflect larger expenditures by private agricultural research in Latin America compared with the other regions, the effects of fiscal stress on investment compression as a whole, and possible underinvestment in research.

Snapshot indicators, including those presented in Table 2, suffer from deficiencies. They provide no meaningful information about the adequacy of national funding levels to meet the challenges faced by research, about the likely payoff from research spending at different funding levels, about whether funding is effectively utilized, or about the capacity of the research system to efficiently absorb additional funding. Consider the example of a low-income country with relatively small shares of GDP and public expenditures allocated to agricultural research. The government may actually be overinvesting in agricultural research if greater reliance on technology spill-ins than on home-grown research is a more efficient way to inspire technological change (Birdsall and Rhee, 1993). Some developing countries have relatively high "snapshot indicators" simply because they attract more donor aid (e.g., Malawi), while others at a similar level of income do not (e.g., Nigeria).

Snapshot indicators, then, can be misleading and should be used with great caution. There are no universal standards or benchmarks that all developing countries should adopt. What is appropriate is country and context specific. Furthermore, when such funding indicators are applied, as undoubtedly they will be for comparative purposes, it is preferable to use them in tandem rather than relying on a single measure.

Funding Decision Rules and Policy Performance

The widespread use of snapshot indicators underscores the difficulty in forecasting future research costs and benefits accurately, and in judging the suitability of agricultural research outlays on that basis. If they are to be used, it is important to do so in a manner that conveys meaningful information to policy makers. For government officials charged with financing a range of activities, the snapshot indicator should be defined in units of what they have to spend, i.e., public expenditures. For other policy makers in need of research spending information, it is important that agricultural research services emphasize that the benefits of research, quite intentionally, are felt well beyond the agricultural sector and that it is national welfare (or income) that they are attempting to influence.

In both cases, the indicator values for a country should be compared with regional values derived from "better performing" countries that are economically and institutionally very similar. In other words, the appropriate snapshot indicator should be drawn from a class of similar countries. Rarely is a snapshot indicator for an upper-income OECD country, with a small agricultural sector and many public resources, an appropriate basis of comparison for a low-income, agrarian nation with few public resources and many constraints on growth.

But for a multidimensional problem, any single indicator is more likely to obfuscate than enlighten. At some point, those demanding resources for agricultural research will have to convince their financiers that their program of work is likely to be a solid economic investment. The difficulties in formally estimating research costs and payoffs are well-known: technology inflows are difficult to predict; research costs hinge on uncertain experiment durations and difficult-to-predict advances in scientific practice; all research has an element of uncertainty; and those scientists with the expertise needed to predict possible research outcomes are often the same group that would benefit from increased funding. Even so, there is little substitute for demonstrating that research has paid off in the past, is well-managed at present, and has a high probability of producing significant benefits in the future (even if these are rough approximations).

Sometimes even rough approximations of research benefits are unavailable, not credible, or indeterminate. In such cases, policy makers may need to rely on indirect evidence of the adequacy of government support for agricultural research—such as productivity trends, observed technology gaps, and spending levels in competitor countries. More specifically, the following may indicate deficiencies in research funding:

- slowdowns in agricultural productivity growth within the country;
- wide gaps in productivity between the country and its competitors;
- evidence of promising but as yet untapped opportunities for generating technology;
- higher spending on agricultural R&D by near-competitors.

A more direct sign of funding deficiencies is fiscal stress within the research system itself, especially when it takes the form of underutilized research capacity.

Even if the research system can demonstrate that agricultural research investments are likely to pay handsome returns, this does not necessarily mean that it is strategically appropriate for government to finance such research (Pradhan 1995). In a discussion of future prospects for funding science and technology in the USA, Daryl E. Chubin, a director in the National Science Foundation, remarked (1996):

> "...the Federal Government, the executive and legislative branches alike, was never organized to manage the pluralistic, decentralized R&D enterprise. If they cannot link R&D funding to national goals, they will simply not look after the investments in a coordinated and flexible manner.... What the size of the R&D enterprise should be will increasingly depend on how much we know about R&D investments and their performance, and how well we manage the portfolio relative to other federal expenditures in any given year" (p.11).

Showing agricultural research to be an effective instrument for achieving national goals and then marshaling adequate and objective evidence that the research system is efficiently and effectively focusing its efforts in this direction are critical exercises for ensuring sustained, coordinated funding support (Chubin 1994). This goes beyond accountability, in the sense of demonstrating output, value-for-money, and impact of research. It requires that agricultural research leaders and policy makers share a clear and specific vision of how agricultural research efforts will help achieve national goals and objectives. The ability to formulate, articulate, and gain consensus on such a vision, and to translate it into a demonstrable reality, increasingly determine whether agricultural research funding has been set at a level commensurate with the development challenges posed for it.

References

Alston, J. M., J. A. Chalfant, and P. G. Pardey. 1995. Technical Progress and Structural Change in OECD Agriculture. In *Agricultural Research in an Era of Adjustment*. Ed. S. Tabor. Washington, DC: World Bank-ISNAR.

Alston, J. M. and P. G. Pardey. 1996. *Making Science Pay: The Economics of Agricultural R&D Policy.* Washington, DC: American Enterprise Institute.

Anderson, K. 1995. Lobbying Incentives and the Pattern of Protection in Rich and Poor Countries. *Economic Development and Cultural Change* 43(2):401-424.

Benyon, J. 1995. The State's Role in Financing Agricultural Research. *Food Policy* 20(6):545-550.

Birdsall, N. and C. Rhee. 1993. Does Research and Development Contribute to Economic Growth in Developing Countries? Policy Research Working Paper 1221. Washington, DC: World Bank.

Bredahl, M. E., W. K. Bryant, and V. W. Ruttan. 1980. Behavior and Productivity Implications of Institutional and Project Funding of Research. *American Journal of Agricultural Economics* 62(3):371-383.

Brown, P. 1994. Funding for Agricultural Research in the Development Cooperation Community. Mimeo prepared for USAID, Washington, DC.

Byerlee, D. 1994. Technology Transfer Systems for Improved Crop Management: Lessons for the Future. In *Agricultural Technology: Policy Issues for the International Community.* Ed. J. Anderson. Wallingford, UK: CAB International.

Byerlee, D. and P. Pingali. 1995. Asian NARS: Frustrations and Fulfillments. In *Agricultural Competitiveness: Market Forces and Policy Choice.* Eds. G. Peters and D. Hedley. Proceedings of the 22 International Conference of Agricultural Economists, 22-29 August 1994, Harare, Zimbabwe. Pp. 685-700. Vermont: Dartmouth University Press.

Chubin, D. E. 1994. The Federal Context for Funding Agricultural Research. In *Evaluating Agricultural Research and Productivity in an Era of Scarcity,* Ed. W. Burt Sundquist. Proceedings of a Symposium Sponsored by NC-208, Department of Agricultural and Applied Economics, University of Minnesota. Minneapolis, USA: University of Minnesota.

Chubin, D. E. 1996. Reculturing Science: Politics, Policy and Promises to Keep. *Science and Public Policy* 23(1):2-12.

Dasgupta, P. and J. Stiglitz. 1980. Industrial Structure and Innovative Activity. *The Economic Journal* 90:266-293.

De Janvry, A. and J.-J. Dethier. 1985. Technological Innovation in Agriculture: The Political Economy of Its Rate and Bias. CGIAR Study Paper No. 1. Washington, DC: The World Bank.

Dollar, D. 1993. Technological Differences as a Source of Comparative Advantage. In *American Economic Review, Papers and Proceedings of the 10th Annual Meeting*. Pp. 431-435. American Economics Association.

Donovan, P. A. 1995. The Management, Funding and Organisational Structure of Agricultural R&D in Zimbabwe, Malawi and South Africa, Parts I and II. *Agricultural Systems* 47:260-290.

Echeverría, R. G. (ed). 1990. *Methods for Diagnosing Research System Constraints and Assessing the Impact of Agricultural Research*. Vol. 2. Assessing the Impact of Agricultural Research. The Hague: ISNAR.

Echeverría, R. G. (1991). *Assessing the Impact of Agricultural Research*. The Hague: ISNAR.

Echeverría, R. G., E. J. Trigo, and D. Byerlee. 1995. Effective Financing of Agricultural Research and the Advancement of Science in Developing Countries. Background note prepared for the World Bank Conference on Environmentally Sustainable Development, Washington, DC.

Englander, A. S., R. Evenson, and M. Hanazaki. 1988. R&D, Innovation and the Total Factor Productivity Slowdown. OECD Economic Studies, No. 11, pp. 1-40. Paris: Organisation for Economic Co-operation and Development.

Evenson, R. E. and C. E. Pray. 1991. *Research and Productivity in Asian Agriculture.* Ithaca, USA: Cornell University Press.

Evenson, R. and M. W. Rosegrant. 1993. Determinants of Productivity Growth in Asian Agriculture: Past and Future. Mimeo presentation to the AAEA Workshop on Post-Green Revolution Agricultural Development Strategies: What next? Orlando, Florida.

FAO. 1994. Funding Agricultural Research in Sub-Saharan Africa. Proceedings of an FAO/SPAAR/KARI Expert Consultation, FAO Publication: Nairobi, Kenya.

Fisher, F. M. and P. Temin. 1973. Returns to Scale in Research and Development: What Does the Schumpeterian Hypothesis Imply? *Journal of Political Economy* 81(1):56-70.

Folster, S. 1995. Do Subsidies to Cooperative R&D Actually Stimulate R&D Investment and Cooperation? *Research Policy* 24(3):391-402.

Gelp, E. and Y. Kislev. 1982. Farmers' financing of agricultural research in Israel. *Research Policy* 2:321-327.

Garelli, S. 1996. The Fundamentals of World Competitiveness. In *IMD World Competitiveness Yearbook*. Lausanne, Switzerland: IMD.

Griliches, Z. 1964. Research Expenditures, Education and the Aggregate Production Function. *American Economic Review* LIV(6):961-974.

Griliches, Z. 1979. Issues in Assessing the Contribution of Research and Development to Productivity Growth. *Bell Journal of Economics* 10(1):92-116.

Griliches, Z. 1994. Productivity, R&D and the Data Constraint. *American Economic Review* 84:1-23.

Haggblade, S. and P. Hazell. 1989. Agricultural Technology and Farm-Non-Farm Linkages. *Agricultural Economics* 3:345-364. (Special Issue)

Hardin, L. S. 1994. Whence International Agricultural Research? *Food Policy* 19(6):561-567.

Hayami, Y. and V. W. Ruttan. 1985. *Agricultural Development: An International Perspective*. Baltimore, USA: Johns Hopkins University Press.

Howe, J. D. and D. G. McFetridge. 1976. The Determinants of R&D Expenditures. *Canadian Journal of Economics* IX(1):57-71.

Huffman, W. E. and R. E. Evenson. 1993. *Science for Agriculture: A Long-Term Perspective.* Ames, USA: Iowa State University Press.

Irvine, J., B. R. Martin, and P. Isard. 1990. *Investing in the Future: An International Comparison of Government Funding of Academic and Related Research.* Report of a Study Sponsored by the UK Advisory Board for the Research Councils and the US National Science Foundation. USA: Edward Elgar Publishing Company.

Jaffe, A. B. 1988. Demand and Supply Influences in R&D Intensity and Productivity Growth. *The Review of Economics and Statistics* 70:431-437.

Kim, H. 1993. *Building Scientific and Technological Infrastructure in Developing Countries.* Washington, DC: Economic Development Institute of the World Bank.

Knutson, M. and L. G. Tweeten. 1979. Toward an Optimal Rate of Growth in Agricultural Production Research and Extension. *Journal of Farm Economics* 61:70-76.

Lichtenberg, F. R. 1987. The Effect of Government Funding on Private Industrial Research and Development: A Re-Assessment. *Journal of Industrial Economics* XXXVI(1):97-104.

Lichtenber, F. R. 1992. R&D Investment and International Productivity Differences. Working Paper 4161. Cambridge, USA: National Bureau of Economic Research.

Manikow, N. G., D. Romer, and D. N. Weil. 1992. A Contribution to the Empirics of Economic Growth. *Quarterly Journal of Economics* 107:407-437.

Mansfield, E. 1982. How Economists See R&D. *Research Management* 25(4):23-29.

Ndiritu, C. G. 1994. Funding of Agricultural Research in Sub-Saharan Africa. Paper presented at the NARS-TAC Meeting in Bouaké, Côte d'Ivoire.

Pardey, P. G. and J. Roseboom. 1989. *ISNAR Agricultural Research Indicator Series: A Global Data Base on National Agricultural Research Systems.* Cambridge, UK: Cambridge University Press.

Pardey, P., G., J. Roseboom, and J. R. Anderson. 1991. *Agricultural Research Policy: International Quantitative Perspectives.* Cambridge, UK: Cambridge University Press.

Pinstrup-Andersen, P. 1994. World Food Trends and Future Food Security. Food policy report for IFPRI. Washington, DC: International Food Policy Research Institute.

Pradhan, S. 1995. *Evaluating Broad Allocations of Public Spending*. Washington, DC: World Bank.

Premchand, A. 1993. *Public Expenditure Management.* Washington, DC: International Monetary Fund.

Ravenscraft, D. and F. M. Scherer. 1982. The Lag Structure of Returns to Research and Development. *Applied Economics* 14:603-620.

Roberts, K. and M. L. Weitzman. 1981. Funding Criteria for Research, Development and Exploration Projects. *Econometrica* 49(5):1261-1288.

Romano, R. E. 1991. The Optimal R&D Policy: Patents, Public Funding, or Both *Southern Economic Journal* 57:703-718.

Romer, P. M. 1990. Endogenous Technological Change. *Journal of Political Economy* 98(5):71-102.

Sexton, R. J. and T. A. Sexton. 1996. Measuring Research Benefits in an Imperfect Market. *Agricultural Economics* 13:201-204.

Shah, A. 1994. The Economics of Research and Development. Policy Research Working Paper 1325. Washington, DC: World Bank.

SPAAR. 1996. Sustainable Financing Initiative: Progress Report. Presented to the 16th SPAAR Plenary Session, Kampala, Uganda. Washington DC, USA: Special Program for African Agricultural Research.

Tabor, S. R. (ed). 1995. *Agricultural Research in an Era of Adjustment: Policies, Institutions, and Progress.* EDI Seminar Series. Washington, DC: Economic Development Institute of the World Bank and ISNAR.

Thirtle, C. 1986. A Summary of Arguments for and against the Public Provision of Agricultural R&D. Manchester Working Papers in Agricultural Economics, WP/O, Manchester University, Great Britain.

Umali, D. 1991. *Public and Private Sector Roles in Agricultural Research: Theory and Evidence.* Washington, DC: World Bank.

USAID. 1995. Public, Private and Independent Sectors in Sustainable Development. LAC TECH BULLETIN No. 10. Washington, DC: US Agency for International Development.

U.S. Congress, Office of Technology Assessment. 1995. *Challenges for U.S. Agricultural Research Policy.* OTA-ENV-639. Washington, DC: US Government Printing Office.

Voon, J. P. 1994. Measuring Research Benefits in an Imperfect Market. *Agricultural Economics* 10:89-93.

Von Braun, J., R.F. Hopkins, D. Puetz, and R. Pandya-Lorch. 1993. Aid to Agriculture: Reversing the Decline. IFPRI Food Policy Report. Washington, DC: International Food Policy Research Institute.

White, F. C. and J. Havlicek Jr. 1982. Optimal Expenditures for Agricultural Research and Extension: Implications of Underfunding. *Journal of Farm Economics* 64:47-55.

World Bank. 1981. Agricultural Research: Sector Policy Paper, Washington, DC: World Bank.

Recommended Reading

Alston, J. M. and P. G. Pardey. 1996. *Making Science Pay: The Economics of Agricultural R&D Policy*. Washington, DC: American Enterprise Institute.

Written for both the policy practitioner and agricultural research policy analyst, this text provides a clear and concise review of the economic rationale for agricultural research spending. The text includes a good review of the economic links between research spending and productivity change, as well as the overall economic impacts of research spending. The book is oriented primarily towards agricultural research spending in the USA and other OECD nations, but also provides valuable lessons for policy practitioners in developing nations.

Birdsall, N. and C. Rhee. 1993. Does Research and Development Contribute to Economic Growth in Developing Countries? Policy Research Working Paper 1221. Washington, DC: World Bank.

Birdsall and Rhee challenge the prevailing wisdom that investment in R&D is an important source of growth in low-income countries. Their empirical assessment finds that R&D activity does not contribute to higher income levels, but that higher income levels contribute to a more R&D activity. They conclude from this that R&D activity becomes important only after a country has reached a certain stage of development. Prior to that, they suggest that the emphasis should be placed on facilitating technology spill-ins, or "catching up technologically" rather than advancing the technology frontier.

Bredahl, M. E., W. K. Bryant, and V. W. Ruttan. 1980. Behavior and Productivity Implications of Institutional and Project Funding of Research. *American Journal of Agricultural Economics* 62(3):371-383.

This influential article discusses the ways in which the "mode" of funding agricultural research can have a powerful effect on its efficiency and effectiveness. The authors examine the advantages and disadvantages of competitive, project-oriented financing with institutional financing. They find a number of important, hidden costs to a research effort when there is a shift away from stable, long-term institutional financing.

De Janvry, A. and J.-J. Dethier. 1985. Technological Innovation in Agriculture: The Political Economy of Its Rate and Bias. CGIAR Study Paper No. 1. Washington, DC: The World Bank.

This publication provides a well-reasoned view of the linkages between economic and political forces, on the one hand, and the funding of agricultural research, on the other. The authors review trends in research financing in the developing world, identify past and emerging financing problems, and develop a conceptual framework in which the funding process is set. The importance of political, institutional, economic, and scientific processes in determining funding outcomes is underscored.

Evenson, R. E. and C. E. Pray. 1991. *Research and Productivity in Asian Agriculture.* Ithaca, USA: Cornell University Press.

This collection of articles reviews the evolution of Asia's major national agricultural research systems. The authors link the evolution of agriculture in Asia to the highly variable ways in which Asia's agricultural research systems have developed. The impact of agricultural research in Asia is assessed, and is found to be quite positive. The volume concludes with a discussion of Asia's NARS within the global agricultural research effort. It finds that technology inflows have been very important in the region, and that the region's attention towards maximizing technology inflows has paid rich dividends. Although Asia's NARS spend proportionally less on agricultural research than the other regions of the developing world, returns to research spending have been very high.

Mansfield, E. 1982. How Economists See R&D. *Research Management* 25(4):23-29.

This is an easy-to-read article on the economic role of R&D, for the noneconomist research manager. Mansfield draws on his extensive review of industrial research to explain the role of R&D in economic growth, the risks involved in R&D, and the different factors that can make it a success. He discusses in layperson's terms the levels of returns that justify R&D in economic terms.

Pardey, P. G. and J. Roseboom. 1989. *ISNAR Agricultural Research Indicator Series: A Global Data Base on National Agricultural Research Systems*. Cambridge, UK: Cambridge University Press.

This volume presents a time-series of indicators of agricultural research spending and staffing throughout the developing world. The authors discuss the development of agricultural research systems in each country, describe the data sources used to glean trends in spending and staffing, and provide a comparative analysis of regional spending trends and developments. This book is an invaluable reference for examining intercountry trends in research investment.

Shah, A. 1994. The Economics of Research and Development. Policy Research Working Paper 1325. Washington, DC: World Bank.

This publication reviews the theory of R&D capital and production, and relates R&D activities to market structure and public policy. Drawing on modern approaches to problems of public finance, the author examines the different rationales for public support to agricultural research, both direct, and through the use of tax credits to the private sector. The report provides an excellent overview of the neoclassical theory of investment in R&D capital and the theory of public finance in R&D capital. The study also includes an empirical examination of the effect of R&D tax credits on science and technology spending in Canada.

US Congress, Office of Technology Assessment. 1995. *Challenges for U.S. Agricultural Research Policy.* OTA-ENV-639. Washington, DC: US Government Printing Office.

A careful review of funding trends, mechanisms, and policy debates surrounding agricultural research in the USA. The complementarity of public and private funding, the degree to which funding should be earmarked to specific uses, the balance between upstream and downstream research, and the different mechanisms by which agricultural research funding are allocated in the USA are presented in a easy-to-read form. The book draws the valuable lesson that funding mechanisms must evolve to keep pace with changes in research challenges facing an agricultural research system.

Chapter 2 Capital Investment Policies and Agricultural Research

Helio Tollini

Introduction

Leaders of agricultural research organizations are called on to make difficult but important decisions about capital investment—for example, whether to buy land, to build or buy buildings, to set up laboratories, to invest in machinery and equipment, or to develop human resources. For such forms of research capital, investment of funds is usually necessary. The key questions are how much to invest and in what.

Capital investments build capacity in specific areas of research, thus defining what the organization is able to accomplish over the long term. Research capital, once invested in a particular way, is often difficult to redirect to other purposes. While the same chemistry laboratory could be used for different research programs, such as animal or plant analyses, one would hardly think of substituting a trained soil scientist for a cotton breeder. All this underscores the need, at the outset, to link capital investment closely with agricultural research policy and priority setting.

The nature of agricultural research, then, is such that, once capital investments are made, the research program is more or less defined for years to come. Other expenditures, such as operating costs, although crucial to making real use of research capacity, affect programs only with respect to how well they are executed. They do not set the major boundaries within which the research system operates.

Investment decisions are difficult because capital has a strong time dimension and often generates benefits that are hard to anticipate. Capital investments produce a flow of services over a period of years. A piece of equipment or a building, for example, will generally last many years, providing services in each year. The same is true of human resources. The investment made in training researchers in specific fields of science generates services over many years.

In research, as in other long-gestating activities, evaluating capital investment means estimating future flows of services and transforming them into a single-period decision variable, which in most cases is a comparator of present costs and the present value of expected benefits. Sophisticated evaluation is needed to account for the risks and uncertainties typical of future events and to compare the likely costs and benefits in different time periods. Assigning values to an expected future stream of costs and benefits from a given investment, however, is not easy.

The private sector frequently uses formal evaluation techniques to generate information about the expected returns to investments. Agriculture research institutes, most notably publicly financed ones, rarely do. This chapter argues that the public sector should use such techniques to underpin its research capital investment decisions. The exercise can be complex or relatively simple, depending on the specific needs and on the availability of both data and analytical resources. The systematic use of formal analytical tools will, in any event, improve management perceptions of the financial and economic advantages of different investment strategies. Management will be able not only to make better capital investment decisions, but also to understand more clearly the likely economic and social implications of agricultural research spending as a whole.

The next section discusses the capital investment problem, and relates it to the overall decision-making context of an agricultural research system. The third section discusses key design considerations in formal evaluation of capital investment in agriculture. For the benefit of research managers who are not trained economists and not familiar with investment evaluation techniques, the fourth section presents a simplified, hypothetical example of two quantitative techniques commonly utilized in investment assessment. The fifth and final section presents recommendations.

The Capital Investment Problem

Capital investments account for a significant share of the research costs of a national agricultural research system, mainly during periods of establishment and expansion. For the early 1980s, Pardey et al. (1991) present data on the shares of recurrent expenses (salaries plus operating costs) and capital expenses (as 1981-85 averages) of 43 developing-country NARS. For comparison, the equivalent figure for the USA is also shown.

The developing-country NARS covered by the study had about 20 percent of their agricultural research expenditures as capital investments. The USA was investing only 8 percent of its agricultural research expenditures as capital during the period in question. This of course does not mean that the USA invests less in absolute terms, only that its agricultural research budget is oriented towards recurrent outlays.

The importance of capital spending depends greatly on a research system's stage of development. In the early years, capital investment tends to be a larger share of expenditures than later, when capacity is much more fully developed.

Information for 17 countries in different parts of Africa in 1991 shows their average capital investment was about 14 percent of total expenses. That is not very different from what these countries were investing in the early 1980s, when the corresponding figure was 15-17 percent. For Latin America and the Caribbean, a survey indicated that capital investment in 1991 was a small share of total investment. With the exception of Bolivia (16 percent) and Jamaica (18 percent), other countries were below 5 percent. Most of the necessary investment in the region had been done in previous decades, and many countries were trying to adjust to falling budgets in the aftermath of fiscal crisis. Another reason for the figures being higher in Africa is that external aid to the region is a larger proportion of research spending than in Latin America. And external aid tends to be oriented towards capacity-expanding investment.

As mentioned earlier, capital investments go hand in hand with research priority setting. Different types of capital build capacity for specific types of research. Whether the organization ends up focusing on crops, livestock, forestry, or fisheries; whether it aims to enhance productivity, conserve the environment, or both; whether it is more upstream or downstream; whether its research is primarily strategic or applied—its orientation depends on the type of capacity built through capital investments. There is only limited flexibility in the use of certain forms of capital and, therefore, in the research program that can be executed. For this reason, a research system's priorities are largely decided at the time capital investments are made.

Capital investment decisions are subsidiary to decisions on economic policy, agricultural policy, science and technology policy, and agricultural research policy. Figure 1 illustrates the way in which agricultural R&D investment decisions are framed—at the top, by sector and development goals and strategies, and at the bottom, by project and program performance and potential. In terms of their role as a means of effecting fundamental change, capital investments are the focal point for interaction between policy decisions and performance capacity.

Capital investment decisions should be closely linked to the definition of overall agricultural research policy. In that policy, the objectives of the research organization need to be clearly defined, along with the overall level of funding and priorities for research expenditures. With known objectives and priorities, the type of research capacity that will be needed becomes clear.

Poor research investments can often be traced to imprecise agricultural research policies. If policy objectives are ill-defined, or not relevant to what agricultural research can do, there is a real risk that research programs will fail to address a country's key technological constraints.

When investments are being designed, it isn't enough for policy to indicate, for example, that research should contribute to economic development or to reduced regional income disparities. Objectives have to be specified in terms that agricultural research can readily address. For example, improving the inter-

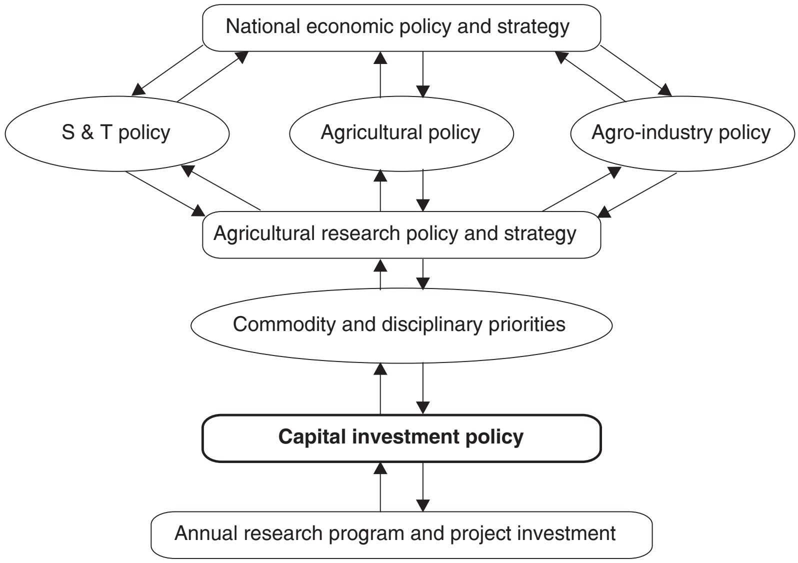


Figure 1. The nested agricultural research capital investment decision context

national competitiveness of corn and coffee producers, or increasing the income of urban rice and bean consumers, or reducing poverty in a certain region of the country, or curbing water pollution from chemical fertilizers and pesticides are examples of policy objectives that research could usefully address. Once the objective, or mix of objectives, is clearly specified, priorities can be set and the research program laid out in light of available resources.

Besides being in line with national S&T or agricultural policies, research investments must also be economically viable. Developing countries have many competing and pressing needs such as better health care, education, and infrastructure for communications, transportation, and energy. It is, in a sense, remarkable that they still invest public resources in agricultural research. An inefficient or ineffective research organization is a serious burden on a developing country. Research managers should therefore take a keen interest in generating returns to society and in showing their stakeholders that they are investing in relevant programs. Ex ante and ex post analyses of investments are ways to increase the efficiency and effectiveness of investments and to ensure transparency and accountability.

Investment in agricultural research capacity tends to be lumpy, irreversible, and relatively inflexible. Long-term priorities, then, should be set before such investments are undertaken, and all investments should be screened for their technical, social, and economic feasibility. In most matters, mistakes carry costs; mistakes in investment in agricultural research capacity convey costs that may linger for many years.

Agricultural research investments are sometimes partially motivated by the sudden arrival of investment finance. Experience suggests that the risk of bad investment goes up when grants are easily had. Grants may steer research programs in directions that developing-country societies don't perceive as priorities. They may also divert operating resources from other programs with larger social benefits or of greater interest to local people. In these situations, investment programs are not sustainable.

Even when investments are financed with loans, research leaders sometimes treat these as grants, since their organization may not have to repay the funds. The notion that investment is a "gift" from abroad can easily lead to waste and inefficiency. Pressure on macroeconomic policy makers to mobilize hard currencies, pressure from donor agency employees to increase their lending activities, and research managers' interest in having bigger and better equipped research programs constitute a set of institutional incentives not always conducive to rational and participatory identification and appraisal of agricultural research investment.

Prestige can be an important motive for investment. Financiers may attach considerable importance to seeing "monuments" to their spending, and scientists gain prestige from working with the latest equipment or on cutting-edge problems. It is difficult to guard against this motive trickling into the investment decision-making process. For often, the argument in favor of the "most prestigious approach" will be that anything less than the best simply isn't good enough. In situations where prestige seems to be driving decision making, it is useful to open up the investment analysis to disinterested parties and ensure that a rigorous assessment of investment alternatives is conducted in a professional and transparent manner.

In general, the more readily available the funding for agricultural research, the more careful research leaders should be in making capital investments. Regardless of their source, resources should not be committed to capital investment until the policy framework for agricultural research is well defined, particularly the general direction of research and the areas in which additional capacity is required. Thereafter, investment should proceed only after a careful and thorough review of the options and of the feasibility of the desired approach.

Considerations in Investment Design

Research managers have many factors to take into account when making their investment decisions. This section discusses some of the more important considerations in designing agricultural research investments.

Complementary expenditures

Many countries that don't have enough money to operate their existing research system continue nevertheless to invest in new research capacity. This only adds to the problems associated with recurrent costs, with the additional capacity destined, from the outset, to underutilization.

In the first place, capital investments must be balanced and complementary. For example, about three decades ago in Latin America, it was common to build research stations without having the resources to staff them adequately. Sometimes a few agronomists were assigned to the stations along with secretarial staff and field workers. But these scientists could not fully exploit the installed capacity in the research station. The notion of building facilities to "attract" scientific expertise is quite common and can result in a serious waste of resources. Ideally, the development of human capital—a long-term process—should proceed in tandem with the development of physical facilities.

Another type of complementary expenditure is operating expenses. Funds are needed for necessities such as fertilizers and other inputs used in experiments, fuel for travel, and staff per diems for on-farm research. Unfortunately, there is often not enough money to cover such expenses, although farm fields and cars may well be available. These well-known problems are discussed at greater length in Chapter 3. Suffice it to say that decisions on new investments must be linked closely to decisions on how to overcome inadequate funding for operations and maintenance.

In such situations, the investment decision may involve both the addition of new capacity and the elimination of excess (possibly outdated) capacity. For example, a research institute may need to develop new scientific expertise but finds itself with substantial excess capacity because of inadequate recurrent finance. The excess capital may become a serious burden for it draws on scarce recurrent budget resources. Thus, managers may have to consider eliminating part of their existing capital stock (fields, buildings, equipment, staff) to make room for new priority investments within their likely envelope of operating expenditure resources. The investment problem then becomes one of estimating the total costs and benefits of both adding and subtracting capacity, subject to an *operating expenses constraint. Given the usual difficulty in shedding resources, especially for public sector organizations, it becomes very important to assess the administrative feasibility of remolding institutional capacity, particularly when operating resources are a serious constraint.*

Research institutions often make capital investments without considering the costs arising from the depreciation and maintenance of capital. Nothing lasts forever, and there is a need to maintain, replace, and modernize all forms of capital. These costs should be estimated at the time decisions on capital investment are made, in order to guarantee the sustainability of the investment. The investment has to pay for itself (depreciation) and to keep itself operational (maintenance) over its life cycle. The shorter the economic life of the investment, the greater the replacement costs. The more fragile the investment, the higher the depreciation and maintenance costs. All too often, investment proponents argue that their investments will last a lifetime, requiring little maintenance or repair. In practice, however, many agricultural research institutes have storerooms full of inoperative equipment because of poor planning of repair and replacement costs.

Scientists are perhaps the single most important investment in a research system. Human capital, to be effective, requires periodic updating through in-house training, conference and seminar participation (both locally and abroad), and refresher courses. To stay abreast of scientific advances, scientists also need access to libraries and other information resources such as the Internet. Over time, these needs are likely to cost more than the initial scholarship cost of a postgraduate degree. Without constant updating, human resources can depreciate rapidly, constituting a "disinvestment" loss to the research system.

Sunk costs

Although often overlooked, there is some potential for molding existing research capacity to new uses as a substitute for new investment. Many research organizations have adapted old buildings and field stations, for example, to meet new needs. Finding creative ways to use the "sunk costs" of a research system may be the most appropriate reaction to fundamental changes in priorities. In these instances, the investment cost is often less of an issue than the design of a new organization or set of functions for the "redirected" research capacity.

Globalization

The increasing interdependence among nations raises new opportunities and challenges for national research systems, requiring them to reassess their objectives, priorities, programs, and organizational structure. In a truly global R&D marketplace, careful evaluation of capital investment becomes even more critical. The risks of investing in capacity that may prove unnecessary over the short term are high, particularly for countries that are now integrating their R&D systems with global sources of R&D.

Globalization raises new questions about the need to invest in local public capacity to undertake agricultural research (Tabor, Tollini, and Janssen 1996). There is no single answer, of course, as to which research should be done in which country. Globalization is, however, revealing a great deal of unnecessary duplication of effort. As the global R&D market develops, all countries will need to reassess their research objectives and priorities and decide who should fund the research and who should execute it.

For NARS leaders, opportunities for using technologies developed in other countries are increasing rapidly. Each country has to evaluate what is more cost-effective and beneficial for its people: to invest in a given research program at home or to acquire the related technology from abroad. Bozzini (1997) provides a vivid example: "Notwithstanding the fact that tomatoes are a very important crop for Italy, now most, if not all, modern hybrids and varieties are obtained elsewhere."

Institutional life cycle

An important aspect to consider when analyzing capital investment is an organization's stage of development. In a phase of research system expansion, with additional resources available for new objectives and programs, capital investment is a large share of total expenditures. In a phase of contraction, where the organization has already accomplished most of its objectives, has been ineffective to the point of exhausting support from its stakeholders, or is ready to tap new and more efficient external sources of technology, the share of capital investment in total agricultural research spending decreases.

In an expansionary phase, capital investment decisions have to take a long time horizon into account. Long-term objectives, priorities, and programs need to be defined and carefully considered. While this may seem obvious, it is frequently ignored when resources are easily obtained. In expansionary periods, the ready availability of funding may force excessively quick decision-making.

In a phase of contraction, resources may be made available from outside donors for specific projects that do not completely agree with local interests. The conflict between the need to downsize because of fiscal restraint and the desire of scientists to expand their research may result in adoption of projects that have come not only with outside funding but also with outside agendas. The situation becomes even more complicated when several donors bring narrowly targeted investment projects to a research system. In this case, local capacity may be diverted away from the national agenda. It may, then, be a better use of resources to allow the research system to contract than to mount low-priority research efforts.

Choice of location

An important factor in investment decision making is where to locate the new capacity. In which research institute should new capacity be situated? And should it take the form of new research programs or be built into ongoing programs? Answering these questions often requires investment designers to make judgments about possible economies of scale and scope.

Management has to decide which institutes can grow and benefit from economies of scale and which ones cannot grow because diseconomies of scale would prevail. When investment aims to create new research programs, it is equally important to consider economies and diseconomies of scope. As in any industrial firm, economies of scope are at play in research organizations, and the degree of specialization or diversification of a given research institute will depend on them. Even if cost structures are not as well known in a public research organization as in a private firm, costs of specialization or diversification can be roughly estimated by research managers and some idea of the nature of economies or diseconomies of scope may be formed. Such information should help guide the decision on whether to diversify a given research station by adding new activities to it or to develop the new activities in a new station.

Buying, renting, replacing

Research managers sometimes have the option to buy or rent capital such as agricultural equipment. They may also be able to buy the service provided by the capital goods—that is, contract a firm to do the work using its own equipment, labor, or other resources. In deciding whether to buy or rent, the manager needs to compare rental costs with costs of buying minus the salvage value. And when considering renting capital goods or buying capital services, an evaluation of the reliability and viability of the providers is needed, particularly in time-sensitive (field-related) tasks.

Similarly, there is the question of whether to replace a depreciated machine (a tractor, for instance) or a not-yet-fully-depreciated machine with a new model. A simple comparison of the variable average cost of the old equipment with the total average cost of the new equipment is needed to evaluate the tradeoffs. But in this instance, judgments about the availability of spare parts and the adequacy of local repair capacity is also needed. All too often, a machine is replaced, and then, to the manager's surprise, a lack of spare parts or trained repair personnel renders the new machine virtually useless.

Centralized versus decentralized investment planning

Investments in agricultural research can be both jurisdiction-specific and national in scope. While some basic and strategic research may be designed to generate technologies that can be diffused nationwide, much agricultural research aims to benefit a specific location or jurisdiction—cotton, maize, or palm oil farmers in some area; a specific watershed or agroecological zone; a politically-defined region such as a province or state. In principle, research specific to a location or jurisdiction could be designed, financed, regulated, operated, and even maintained by local authorities. All too often, though, agricultural research investments are centrally designed, even if the benefits are expected to be enjoyed primarily by stakeholders in a single locality.

But the design of an agricultural research investment requires considerable judgment, both technical and administrative. Thus, scientists and central government officials often play leading roles. But if local beneficiaries aren't involved in the design, they will have no sense of local "ownership" and therefore little interest in financing, maintaining, or otherwise supporting the investment. And the orientation of the project may shift for the worse. Devolving authority for investment design to local stakeholders, particularly where the intended benefits are clearly jurisdiction-specific, may slow the pace of development. But it will probably improve the relevance and sustainability of the investment. The real organizational challenge is to combine local participation with technical and administrative expertise in both the design and evaluation of investment alternatives. How this is done will, no doubt, vary from one situation to another.

Coping with uncertainty

When the future of research is uncertain, it is prudent to go for flexibility —that is, to opt for forms of capital investment adaptable to different purposes, even if there is some loss of efficiency. Uncertainty may arise from poorly defined research objectives, from risks associated with globalization, from shifting market conditions, or simply because changes in science and potential payoffs from different kinds of research are hard to predict. Where uncertainty is high, the flexibility to change the course of research over time should get high priority in the investment design process. Still, it bears repeating that research investments—in people, facilities, and equipment—are by their very nature not highly flexible, and a specific type of capital investment may be required to address specific priorities.

There are several ways, then, to build flexibility into research project design: refraining from giving highly specialized training, renting instead of buying machines and equipment, and building multipurpose labs, to name a few. When the "temporary" capital investment is later used as a sunk cost to build capital to the right type and size, the costs of flexibility are reduced. Such measures have to be evaluated in terms of the tradeoffs between "storing" research capital until needs become clearer and the possible costs of making the wrong choice in an uncertain environment.

Quantifying Costs and Benefits of Research Investments

Putting numerical values on the costs and benefits of research investment is often avoided, or deemed impossible, by research managers, donor agencies, and national governments. This is a pity, for it is not so much the particular cost-benefit coefficient that one is seeking, but the process of rationalizing decision-making within the research enterprise.

It is certainly possible to assess the likely costs and benefits of adding research capacity. Clearly, the act of assembling relevant data about an investment improves a research manager's information and understanding about his or her operations, especially the potential contribution of proposed investment projects to national development aims laid out in agricultural and technology policies.

Assessing the costs and benefits of a research investment requires costly information and a process of data gathering. But, in practice, the difficulties with data gathering and with quantitative methods of analysis are more than compensated by the information gain. Moreover, experience with research-returns data gathering and investment analysis helps research managers to adopt more transparent procedures. In effect, it allows them to explain their investments in language acceptable to finance ministries and other agencies charged with assessing public investment outlays. Understanding new investments in terms of expected costs and benefits also reduces the chance of major factors being overlooked, to the advantage of all involved.

The desirability of a capital investment depends on how well the benefit stream compares with the cost stream. Costs are easier to evaluate than benefits, partly because they are likely to be registered over a short period. It is important, though, to take into account the net additional recurrent costs associated with operating the newly created agricultural research capacity, as well as the costs of maintaining and depreciating that capacity over time. These "neglected" cost factors can be quite significant and must be included to produce an accurate picture of the total cost stream.

Investment benefits are more difficult to calculate. They have to be clearly identified and, where possible, assigned a monetary value, which is not always easy to do. Scientists have an important role to play here. They can give their "best technical estimate" of output increases, cost reductions, or cost and output variability (from better pest management, for example) that *should* result from a given investment in new research capacity. Since scientists may have a vested interest in attracting new investment, it is wise to call on panels of scientists to present their views or to invite disinterested external experts to validate local scientific estimates. Scientists can also comment on the likely positive and negative effects of a research investment on the environment.

While scientists may be able to identify technical benefits themselves, collaboration with economists may be required when it comes to assigning monetary values. The economists need to assess the changes in markets and prices that are likely to be associated with particular types of innovation. When a country (or a region) is a small producer and a price-taker, it is quite reasonable to assume that prices will remain the same. When these conditions do not hold, then technological innovation will alter prices. Furthermore, prices will change over time for reasons quite unrelated to technological change. A forecast of the costs of agricultural inputs and the prices of agricultural outputs is needed to convert the physical-change estimates (supplied by scientists) into monetary equivalents. Typically, economists working for agricultural planning agencies, planning ministries, or even the larger donor agencies can help provide such information.

When benefits can't be translated into monetary terms, they have to be accounted for in a descriptive way. This is common practice when dealing with environmental benefits or with the social benefits that accrue from improving regional balance or reducing poverty. Rather than force some (often senseless) measure of monetary value on a nonmarket outcome, it is better to report the benefit in physical terms and give it a weight in the investment decision-making process after all the economic and financial calculations have been completed.

Whenever there is doubt about the value of a cost or a benefit, the analyst can use parametric analysis (i.e., provide a range of possible outcomes). The fact that future events are uncertain is not a reason to avoid investment analysis. Research managers and scientists can, with some degree of assurance, define interval limits within which a future event is likely to occur. This also provides research managers with information on the sensitivity of the results to different values of some variables and therefore on the importance of those variables to the analysis.

Once a table of research investment costs and benefits is developed, then decision-making criteria must be selected and applied. The following discussion concentrates on two commonly adopted criteria: net present value and internal rate of return. These, or variations of them, are the most common criteria for evaluating both public and private investment. The discussion is kept general, and is designed to provide a simple example of the methods rather than the advantages or disadvantages of these techniques.

Net present value

As the name indicates, the net present value (NPV) does two things: it nets the benefits by subtracting the costs from the benefits for each period of time, and then sums up the stream of future net benefits into a value corresponding to the present or current period.

Summing all the net benefits for each year gives an idea of the total value of net benefits, but the flow of net benefits has to be discounted over time. To transform future values into present values, a discounting rate is used. Public agencies should follow recommendations of authorities in macroeconomics about the discounting rate appropriate to the economy. Discount rates are related to the opportunity cost of capital in the economy—to the idea that if capital is not used for agricultural research, the resources could be invested in another sector of the economy.

The appropriate discount rate to be used depends largely on the productivity of investment in the economy, the scarcity or abundance of capital, and the range of alternative uses of capital. In practice, most developing countries are capital-poor and have many different investment options. Research investments, which may take many years to yield returns, will need have to have high expected payoffs to justify preempting the use of resources for other investments with shorter payoff periods.

Internal rate of return

The internal rate of return (IRR) is the rate that equates to zero the present value of the stream of net benefits. In other words, this is the rate of return on the addition to the research system's capital stock that the new project is expected to obtain. The higher the IRR of a project, the better the project from the investor's point of view. This is a convenient though imperfect way to compare different projects or to compare the return of a project with some average rate of return for a range of different investments.

Hypothetical example

Suppose a research manager is considering two alternative programs, A and B, for his organization. One might be a corn research program for one region of the country and the other a rice research program for same or another region. Assume that costs, benefits, and net benefits from each of the two alternative investment programs are as specified in Table 1.

Table 1. Costs, Benefits, and Net Benefits for Two Hypothetical Research Programs

	Program A			Program B		
Year	Costs	Benefits	Net benefits	Costs	Benefits	Net benefits
0	0	0	0	1,500	0	-1,500
1	60	0	-60	200	0	-200
2	150	0	-150	200	100	100
3	240	0	-240	50	300	250
4	240	0	-240	50	500	450
5	210	50	-160	50	500	450
6	120	100	-20	50	550	500
7	60	200	140	30	600	570
8	0	400	400	30	650	620
9	0	600	600	30	550	520
10	0	600	600	30	450	420
11	0	700	700	30	300	270
12	0	800	800	30	200	170

Estimating the net present value and the internal rate of return for each of the two projects with a discounting rate of 10 percent yields the following results:

Program A: NPV = US$ 611.09; IRR = 21.80 percent
Program B: NPV = US$ 570.66; IRR = 15.24 percent

With a discounting rate of 5 percent, the net present values would be:

Program A: NPV = US$ 1,241.83
Program B: NPV = US$ 1,382.39

The NPVs and IRRs can be shown graphically by plotting the lines representing the two programs, for discount rates of 5 percent and 10 percent, as in Figure 2.

These results indicate that program A yields higher returns than B. The net present value and the internal rate of return are higher for A. If the estimates are made with a different discount rate, the net present values will be different, and will decrease as the discount rates rise. The choice of the investment option hinges very much on the choice of the discount rate as well as the chosen decision-making indicator (e.g., an NPV or an IRR).

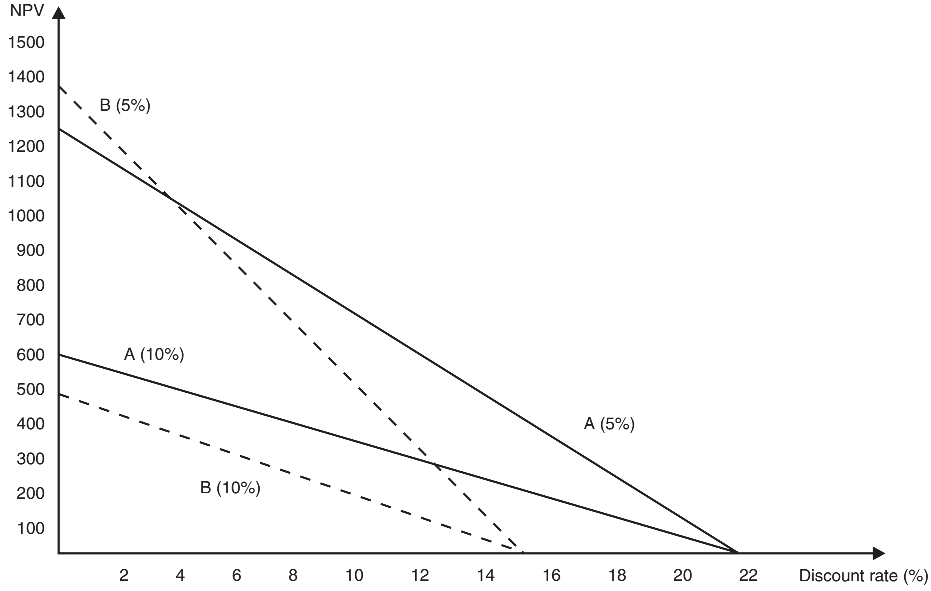


Figure 2. Net present values and internal rates of return for two hypothetical capital investment projects, A and B, using 5% and 10% discount rates

For example, using a discount rate of 5 percent, the NPV for program B is superior to that of program A. According to the IRR criteria, however, program A is still the best investment. This is because using a discount rate of 5 percent, the lines for program A and project B cross at a rate of 4.16 percent. So, if authorities employ a discount rate below 4.16 percent, program B should be chosen. But conversely, program A should be chosen for any discount rate above 4.16 percent. At a discount rate of 10 percent, the lines do not cross and project A is better on both criteria independently of the discount rate.

In actual situations, the investment analyst will use a discount rate appropriate to the actual conditions prevailing in the economy. The discount rate should reflect the opportunity cost of capital in the economy. In general, finance ministry officials are the best source of information about the opportunity cost of capital and the rate to use in such capital investment evaluations. Research managers (or their investment analysts) should obtain an estimate of the relevant discount rate from public finance specialists in the finance or planning ministry.

Recommendations

The use of quantitative criteria like NPV and IRR creates the impression of mathematical accuracy of a point estimate that is often far from the truth. Great care must be taken in generating and evaluating such estimates. The real gain, as noted above, is the decision-making discipline that these trade-off criteria introduce into the process. Assembling information on the costs and benefits of an investment program, and relating those costs and benefits to particular research goals and objectives, improves the overall understanding and management of the research process. The knowledge thus gained strengthens the management function of research organizations. As the quality of knowledge about research costs and benefits improves over time, research leaders are better able to make well-informed investment decisions and to improve their day-to-day management of the research enterprise.

Sometimes, the process of comparing the costs and benefits of different research investments, discounted in the appropriate way, will lead to the conclusion that no new investments (or at least those that are proposed) should be made. It must be kept in mind that low expected returns to research programs may not be the fault of the research institute. They could well be due to adverse economic and agricultural policies or other unforseen circumstances.

As discussed earlier, a sound research investment cannot be made in the absence of a sound agricultural research policy. Particularly in an era of increasing globalization, it is essential for a country to define clearly the rationale for investing in its own agricultural research capacity. Defining a society's agricultural technology problems, and identifying the extent to which domestic capacity must be built to solve such problems, is the starting point for any assessment of agricultural investment options.

If objectives are not clearly defined, priorities cannot be properly chosen and quantitative methods would also be irrelevant. But if objectives are clear and priorities well-defined, then the use of quantitative decision-analysis methods can help improve the information base for decision makers facing a choice among alternative investments. Quantitative indicators, such as an NPV or an IRR, should not be viewed as the ultimate arbiter of whether to invest or not. Rather, they should be used as indicators of the relative importance of the different investments under consideration. If one project has a significantly higher NPV and IRR than a similar alternative, even when using conservative estimates, it is clear that the project with higher returns should be implemented and not the other. When the results are close, other information and criteria must be used to make the final decision.

By no means should formal investment analysis be attempted every time a piece of equipment, building or training activity is under consideration. It should be done, however, whenever a major capacity-building investment is being formulated. What is major and what is minor is highly country-specific, and is something best left to research leaders to decide. Investment analysis makes sense when applied to whole programs or additional programs of research that require capital investment expenditures. Donor financing is typically involved in such cases.

Formal evaluation of agricultural research investments should certainly be carried out when research programs are being considered for external financing. One important reason for this is that the country will have to repay any loans. It is necessary to ensure that the returns obtained with the help of external finances will generate enough resources to pay back the debt. Any major investment, of course, even if domestically financed, requires the best possible ex ante evaluation.

References

Bozzini, A. 1997. Personal communication to the Board of Trustees of ISNAR, March 1997.

Pardey, P. G., J. Roseboom, and J. R. Anderson. 1991. Topical Perspectives in National Agricultural Research. In *Agricultural Research Policy - International Quantitative Perspectives. Eds. P. G. Pardey, J. Roseboom, and J. R. Anderson. The Hague: ISNAR.*

Tabor, S., H. Tollini, and W. Janssen. 1996. Globalization of Agriculture Research: Do Winners Take All? Discussion Paper 96-11. The Hague: ISNAR.

Recommended Reading

Baumol, W. J. 1965. *Economic Theory and Operations Analysis*. Second edition. Englewood Cliffs, USA: Prentice-Hall, Inc.

Chapters 18 and 19 of this book present an introduction to the concept of capital and to the major issues in capital budgeting.

Ward, W. A. and B. J. Deren. 1991. *The Economics of Project Analysis - a Practitioner's Guide*. Washington, DC: World Bank.

A practical discussion of major economic aspects of project evaluation and specific methodologies for dealing with them.

Londero, E. 1987. *Benefits and Beneficiaries - An Introduction to Estimating Distributional Effects in Cost-Benefit Analysis*. Washington, DC: Inter-American Development Bank.

A relatively advanced text to be used by trained analysts interested in introducing distributional aspects in their analysis.

Squire, L. and H. G. van der Tak. 1975. *Economic Analysis of Projects*. Baltimore, USA: The John Hopkins University Press.

A basic book for analysis of projects. Useful for economists charged with evaluation of investments in agricultural research.

Schuh, G. E. and H. Tollini. 1979. Costs and Benefits of Agricultural Research: The State of the Arts. World Bank Staff Working Paper 360. Washington, DC: World Bank.

One of the first discussions of costs and benefits of agricultural research. Although the art has evolved since them, this working paper contains an accessible discussion of the reasons for formally estimating costs and benefits and of problems encountered in this type of analysis.

Alston, J. M., G. W. Norton, and P. G. Pardey. 1995. *Science under Scarcity.* The Hague: ISNAR.

The most comprehensive and updated treatment of the evaluation of investments in agricultural research. Should be used by trained economists.

Gittinger, J. P. 1982. Economic Analysis of Agricultural Projects. Second edition. Baltimore, USA: The John Hopkins University Press.	A classic in project evaluation. Useful to noneconomists, it emphasizes the procedures rather than the complex economic problems involved in project analysis.

Chapter 3
Recurrent-Operating Cost Policies for Agricultural Research

Steven R. Tabor

Introduction

If we subtract salaries, benefits, and capital investment from the total costs of research, the balance is what may be defined as "recurrent operating costs." In this category are the many goods and services needed to exploit and maintain research capacity—laboratory supplies, repairequipment repairs, fuel, and so on.

Not having sufficient operating resources, at the appropriate time and in the right mix, is a common problem in the agricultural research organizations of developing countries. It results in research capacity being underutilized and can seriously undermine research performance over the long term. Various factors are responsible for the problem and, in most instances, research policy reform is needed to correct or at least improve the situation.

Under certain circumstances, not having enough operating resources actually impedes the research system from attracting financing. In reviews of agricultural research projects assisted by the World Bank, the lack of sufficient counterpart operating funds was revealed as a major cause of poor project performance (Pritchard 1990). More generally, the lack of sufficient resources to operate and maintain government institutions has been cited as a major reason for poor public-sector performance and the lack of financial sustainability of externally assisted projects (Howell 1985, Heller 1991, Tabor and Ballantyne 1995).

For most agricultural research systems, actual operating costs are not large, but they are the spending category most vulnerable to economic change. Items typically financed under this heading include office and laboratory supplies, spare parts, transport, communications, water, gas, electricity, rent, library materials, publications, training, and repairrepairs. In practice, this category accounts for 20 to 40 percent of current expenditures in most research systems

(Oram 1985, Pardey and Roseboom 1989). Although the percentage of total expenditures may be relatively small, these costs are difficult to predict accurately and may change quickly for various reasons:

- Remuneration of research personnel accounts for 60 to 80 percent of recurrent spending and for more than 90 percent of local (non-aid) outlays in many of the poorest countries. Wage accords occur unexpectedly and even a small rise in salary and benefits payments, with no change in total recurrent spending, can squeeze out a substantial share of spending on other recurrent operating costs.
- A fair number of items falling under the category of recurrent operating costs are imported. These costs are subject to changes in international market conditions and in exchange rates.
- Fuel, telecommunications, gas, and electricity tariffs are periodically increased, often in a fashion difficult for research leaders to anticipate.
- For specialized scientific equipment, the costs of repair and replacement are also hard to predict, particularly if the items are imported.
- The costs of mounting a field experiment may change during implementation depending on climatic conditions and on progress registered during earlier phases of the research.

Policy makers are aware that insufficient financing of recurrent operating costs can result in important assets being underutilized, laying idle, or deteriorating at an unacceptable rate. But they often face an uncomfortable choice: underfunding such items or suffering the inflationary and debt-buildup consequences of an undisciplined fiscal stance (Chhibber and Shirazi 1991). When savings have to be made, as often they must in economies scrambling to restore financial stability, recurrent operating costs are one of the categories of public expenditure prone to cutbacks (Premchand 1993).

The next section reviews various factors, in addition to changing economic circumstances, that can trigger problems of recurrent operating costs. This is followed by a discussion of the consequences of such problems and options for addressing these issues. The final part provides a brief summary of the chapter.

Causes of Recurrent-Cost Problems

Many factors can trigger recurrent operating cost problems for agricultural research. They may combine in a way that makes it difficult to assess the proximate cause of a given problem. While the symptoms—namely, underutilized or rapidly deteriorating research capacity—may appear similar, appropriate solutions depend heavily on the nature of underlying causes.

Over investment

Overinvestment is a typical cause of insufficient recurrent-cost financing. It refers to an expansion of capital stock at a rate that exceeds the carrying capacity of the economy. Throughout the developing world, heavy investments were made to expand research capacity during the 1960s and 1970s (Pardey and Roseboom 1989). Overinvestment, in a few instances, reflected the effect of lending targets set by different donor agencies. More generally, the rapid growth in research capacity was designed to reduce reliance on the use of costly expatriate scientists in favor of nationals.

In some instances, the number of trained scientists working in NARS increased by 10 to 15 percent per annum, while government revenues stagnated. Thus, as investment continued to add staff and facilities, the gap between the government's capacity to meet recurrent-cost obligations and the research system's requirements became very large indeed.

Badly designed investments

In some cases, agricultural research investments have been unnecessarily expensive to operate, maintain, and repair. Poor project design may saddle a research system with an excessively high recurrent operating cost obligations. This can happen in all facets of capacity-building investment.

There are instances, for example, of office and laboratory facilities having been designed and built in such a way that they require air-conditioning in every office. This was done even though climate control wasn't necessary for most experiments and, more importantly, air-conditioning operating costs were very high. In some projects, scientists have been overtrained for their assigned tasks. They end up returning to their research systems with expectations of having access to sophisticated laboratories and other facilities well beyond the capacity the research system to provide and maintain. In other instances, research institutions have been provided state-of-the-art scientific equipment under donor-assisted projects. Often, the cost of repairing and replacing such equipment is not figured into the cost of the project.

Fiscal collapse

In some developing countries, public finances have simply collapsed. This is often a reaction to past periods of profligate spending, but in some instances it is a response to particularly adverse economic circumstances. In either case, when public finances collapse, so does support for agricultural research. Paradoxically, the "cure" for fiscal collapse is normally fiscal restraint. For many economies undergoing structural adjustment, a prolonged period of fiscal restraint is necessary to restore macroeconomic balance. In practice, this has meant dramatic reductions in public sector outlays for transport, telecommunications, travel, and imported goods (Premchand 1993). Agricultural research institutions are particularly vulnerable to such cutbacks because a large share of their nonwage operating costs consists precisely of those items most likely to be subject to fiscal restraint.

In unstable economies, normal governmental budgetary operations tend to break down. There may well be a wide gulf between what is approved in the budget and what is actually spent. Release of funds to cover expenses occurs only irregularly, arrears may accumulate, and budgetary leakages become the rule rather than the exception. In such situations, the budget is likely to be subject to frequent revision, and the value of what is actually spent will, in any event, be eroded by galloping domestic collapseinflation. Financial uncertainty may become so high that it stops research activity altogether or biases the choice of experiments to those with little or no requirement for recurrent operating-cost resources.

Inadequate compensation of scientists

Sometimes what appears to be a problem of inadequate recurrent costs is really one of inadequate remuneration of agricultural research staff. When wages and benefits are too low, staff may try to manipulate recurrent-cost resources for their own financial gain. The real motive behind field trips, training, attendance at conferences, and even field trials, for example, may be to augment individual earnings. In the extreme cases, when public-sector salaries fall below basic requirements, the research system may degenerate into a form of semisubsistence farming, aimed keeping the research staff fed.

Political neglect

Research systems may suffer from inadequate recurrent-cost financing even when governments have the resources to fund research at an adequate level. Governments may suffer from urban bias, traceable to the lack of a vocal constituency for agricultural research. Frequently there is an imbalance between spending on agricultural extension, which typically has high political visibility, and spending on agricultural research, which may be seen as a kind of behind-the-scenes task. Biases against agriculture or against low-visibility activities in government translate into a bias against funding agricultural research.

But there can also be public-sector bias against agricultural research. Many political leaders believe there already exists a well-stocked "technology shelf" and that it is simply a matter of communicating its contents to farmers. That such a view persists is often cited as a reason why expenditures on agricultural extension in the developing world are four to five times greater than those on agricultural research, while in higher-income economies the ratios are reversed (Huffman and Evenson 1993). If political leaders don't perceive a meaningful role for agricultural research in technological change, then there can easily be budgetary neglect of agricultural research services.

Whether or not agricultural research is considered a low priority (for reasons of urban bias or technological over confidence), the wage bill of the scientific staff will continue to be met. But the funding required for recurrent operating costs will be vulnerable to competition from other, more highly regarded branches of the public sector.

Fiscal rigidity

As noted earlier, recurrent operating costs for agricultural research are difficult to plan and are subject to change. From the perspective of those managing the government budget, this is a problem. In practice, agricultural research has both long-term and short-term (highly time-sensitive) recurrent-cost budget requirements. Most finance ministries, however, operate on an annual budgetary basis and try to stabilize cash flow requirements by spreading disbursements evenly over the year. For most government activities, it makes little difference if the recurrent-cost budget is inadequate for a month or two or is somewhat lower one year than the next. For an agricultural research activity, the lack of sufficient operational resources during a crucial period of the cropping cycle may invalidate years of carefully planned experimentation.

Deficient management

The recurrent-cost problem is often not one of inadequate resources, but of poor management of existing, available resources. Waste, corruption, and poor planning can lead to a situation in which, despite considerable spending on recurrent operating costs, there is still an acute shortage of operating resources for high-priority research. Over time, a poorly managed research institute or system may have difficulty mobilizing sufficient recurrent-cost resources because those providing the money have good reason to doubt that it will be put to good use. A vicious cycle can easily take hold. Poor management leads to a loss in recurrent-cost funding which, in turn, drives poor managers to waste even more resources.[1]

When the management of a research system has only limited budgetary authority, it is relatively easy for recurrent-cost financing problems to arise. In many research systems, management cannot hire and fire employees at will because of the protection afforded by civil service employment. Nor, in most instances, can management unilaterally alter the wage bill because of centrally controlled government procedures for wage adjudication. Even in countries in which agricultural research systems are operated as parastatal bodies, the actions of organized labor tend to reduce the discretionary authority of management over staff remuneration. When research managers have little or no control over the wage bill, other recurrent operating costs become residual expenditure items, easily cannibalized by an excessive wage or employment demand.

[1] Readers are encouraged to refer to Chapter 13 for a review of financial management and options for its improvement.

Donor-assisted projects pose special problems for the management of recurrent operating costs. They typically require the commitment of specific amounts of counterpart resources, and the bigger the project, the bigger the commitment. Externally funded projects, then, tend to have priority access to recurrent-cost resources and may even capture the bulk of them, leaving little for unassisted research projects. In systems that depend heavily on external assistance, the research manager has little choice but to underfund the recurrent-cost obligations of the unassisted portion of the research portfolio in order to maintain aid inflows.[2]

Implications of Inadequate Recurrent Funding

Agricultural research systems are like complex machines: if not regularly operated and properly maintained, they rust and decay. In the extreme, inadequate recurrent-cost financing can bring research institute operations to a halt. Nothing of value is produced, researchers become disenchanted for lack of opportunity to apply their talents, and morale plummets. Should the situation persist, the research system begins to decay. More specifically, here are some of the possible consequences:

- A backlog of overdue repairs and maintenancemaintenance of research equipment and physical facilities accumulates, making it more expensive to restart research operations when funding constraints finally ease.
- Absenteeism rises as researchers seek other ways to occupy their time.
- Research station property is diverted for nonresearch undertakings.
- Well-trained researchers become frustrated and leave the system, in some cases abandoning research altogether.
- The skills and operating capacity of the research staff diminish, due both to reduced flow of research activities and to dwindling contact among scientists working in their respective disciplines.

But most research systems do not suffer from such severe shortages of recurrent-cost resources for any extended period. Even in those that do, mechanisms evolve to allow the systems to cope. It is, however, the sporadic shortfalls in financing that can have the greatest impact on research performance. If scientists become convinced that periodic funding shortages are likely to occur, they will adapt their behavior to deal with the constraint. Such adaptations to intermittent underfunding of recurrent costsoperating costs may include

- a biasing of the research agenda away from long-gestating, operating-resource-intensive research activities, towards activities requiring fewer resources;

2. Strategies for improving the design of donor-assisted investment efforts are discussed in Chapter 6.

- the formation of protective alliances between researchers and donor agency representatives on the assumption that donor agencies will not be affected by shortfalls in recurrent-cost resources;
- overbudgeting of actual recurrent-cost requirements and overstocking of research supplies, materials, and spare parts;
- allocation of large amounts of scientists' time to mobilizing sufficient operating resources;
- development of reward systems for scientists based not on scientific achievement, which is presumed to be limited by the recurrent resource constraint, but on the ability to move into the ranks of administration.

While such practices are a perfectly rational institutional response to periodic shortages of recurrent-cost resources, they cause inefficiency and ineffectiveness in research activities and in the research system as a whole.

Another problem with insufficient recurrent-cost resources is that it makes the research system highly vulnerable to programmatic biases introduced by donors, the private sector, and others willing to provide a small amount of "lifeline" resources. Institutes with recurrent-cost constraints are in a poor position to negotiate with external agencies supplying financing because, without their support, activities might simply cease. Hence, the external financier (be it a donor, private firm, or large farmer) can capture the services of large segments of the research service in exchange for relatively small amounts of recurrent-cost financing. As a result, high-priority research may be neglected in favor of low-priority work that happens to have a willing backer. In fact, the more serious the difficulties with recurrent operating costs, the more vulnerable a research system will be to external influences on its research agenda. This may not do any harm if the research agenda of the external party and that of the NARS coincide, but it would be quite a coincidence if they were.

Options for Overcoming Problems of Recurrent Operating-Cost Financing

Clearly identify the cause and extent of the problem

Many factors can contribute to a recurrent-cost problem. The first step is to identify its proximate cause. Treating the symptoms by mobilizing more recurrent funding may provide a measure of breathing space, but whether this is helpful depends on the degree to which "budget stress" inspires lasting financial solutions or only impairs institutional performance. Table 1 presents some of the causes of the problems of recurrent operating costs as well as possible approaches to dealing with them.

In diagnosing the cause of a recurrent-cost problem, managers should attempt to document the extent and consequences of the problem. While these may be well known, there is often a lack of hard evidence of both the extent of

Table 1. Operating Costs of Agricultural Research: Problem Origins and Reform Options

Causes / Policy options	Over-investment	Poor project design	Fiscal collapse	Inadequate salaries	Budget mismanagement	Poor budget control	Political neglect of research
1. Defer or delay new investments.	X	X	X				
2. Tighten investment appraisal standards.		X			X	X	
3. Forecast future recurrent-cost needs.	X	X			X	X	X
4. Incorporate recurrent-cost needs in budget projections.	X				X	X	X
5. Make recurrent-cost financing problems known to traditional financiers.			X				X
6. Reallocate capital expenditures to augment recurrent operating expenditures.	X		X				
7. Explore all nontraditional sources of financing.				X	X	X	X
8. Identify and eliminate waste and mismanagement of recurrent operating resources.				X	X	X	
9. Restructure research system so that it is affordable given likely ongoing availability of recurrent-cost financing.	X		X	X			
10. Improve terms and conditions of research staff employment.				X			X
11. Improve monitoring and evaluation of recurrent spending.		X			X	X	

Note: X refers to an area of possible research policy intervention.

the problem and its cause(s). Another important reason for concentrating efforts on identifying causes is because a policy of augmenting recurrent-cost resources may, in certain cases, only aggravate the problem. Take, for example, the case of a research system suffering from inadequate recurrent-cost resources because staff salaries are too low. An increase in the recurrent operating budget will likely be "captured" by staff as an income supplement, when recurrent-cost expenditures may have well have been sufficient for research operations in the first place.

Bring the issue to the attention of the main financiers

Documenting the cause and extent of the problem can be a first step in its solution. It is often too hastily assumed that finance ministries and donor agencies suffer from "urban bias" when, in fact, they may not be aware that a serious problem exists. And even when they are, they may need to be convinced that the proposed solutions will work, addressing both the symptoms and the underlying causes.

Ultimately the resolution of the recurrent-cost financing problem requires the full support and cooperation of the main agricultural research system financiers. These agencies must be informed of the consequences of allowing such problems to persist, in terms of both undermining progress from past investment and reducing capacity to address future needs.

Research leaders have a tendency to become upset with finance ministries when essential recurrent outlays are badly underfunded. In some countries, this has led to situations where research leaders and those overseeing their budgets in the ministryfinance ministry were hardly on speaking terms. In practice, it is rare for such an adversarial relationship to contribute to the resolution of a recurrent-cost funding problem. The true challenge is to involve the financiers in a frank and transparent review of the issue, and to arrive at a shared vision of the corrective steps to be taken.

Explore nontraditional avenues for mobilizing recurrent-cost resources

Research systems that suffer from recurrent operating-cost shortfalls often have underutilized facilities, staff, and equipment. Companies or private firms may be willing to "rent" these resources for specific purposes. The revenues generated could then be used to offset the shortfalls. This is already happening in most agricultural research systems. In many countries, the sale of agricultural produce from research station farms is used to augment operating budgets.

Many scientists provide consultancy advice to agribusiness or large farmers, for which either they or their institutes are reimbursed. But there are also instances in which research station fields lie idle, despite their potential to generate significant revenues. And in many cases, for historical reasons, agricultural research institutes occupy prime commercial property, which could bring far higher returns if used for nonagricultural purposes. Here the challenge is to exploit the research system's assets for a suitable balance between research activities and revenue mobilization, while keeping the two kinds of activities separate.

In many countries, research leaders are discouraged from seeking nontraditional funding because of the requirement that proceeds from such activities revert to the general revenues of the treasury. The first step in overcoming this problem is to obtain official consent to pursue such initiatives and to earmark the resources mobilized to augment recurrent-cost budgets.

Many scientists provide consultancy advice to agribusiness or large farmers, for which either they or their institutes are reimbursed. But there are also in-

stances in which research station fields lie idle, despite their potential to generate significant revenues. And in many cases, for historical reasons, agricultural research institutes occupy prime commercial property, which could bring far higher returns if used for nonagricultural purposes. Here the challenge is to exploit the research system's assets for a suitable balance between research activities and revenue mobilization, while keeping the two kinds of activities separate.In many countries, research leaders are discouraged from seeking nontraditional funding because of the requirement that proceeds from such activities revert to the general revenues of the treasury. The first step in overcoming this problem is to obtain official consent to pursue such initiatives and to earmark the resources mobilized to augment recurrent-cost budgets.

Carefully screen new projects for recurrent-cost obligations

One way to avoid problems from the outset is to screen new projects carefully for their recurrent-cost implications. Project officers tend to underestimate these costs. Here are a few examples:

- Where a research institution currently enjoys subsidized electricity, telecommunications, and other publicly provided services, most project proposals assume, sometimes incorrectly, that such advantages will continue for the life of the investment project.
- Projects aimed at institution-building rarely incorporate estimates of the full recurrent costs of maintaining capital works or of the ongoing training needed to keep the skills of project personnel up to date.
- Few project appraisals include the likely ongoing costs of replacing scientific assets that become economically or technically obsolete.
- The costs of replacing personnel who leave the institute due to promotions, transfers, or other forms of attrition are rarely estimated.

If such costs are systematically underestimated, research systems are likely to end up running financially unsustainable projects. While there is no substitute for careful project screening for recurrent-cost implications, certain measures can be taken to offset the tendency towards a downward bias in recurrent-cost forecasting:

- All projects should be required to assess future recurrent-cost requirements as an integral part of project appraisal. Those that don't seriously assess this should not be considered for funding.
- Project preparation guidelines should specify procedures to be used for forecasting recurrent costs, with guidance provided on the inflation factor, utility rates, and depreciation to be used for different types of capital goods.
- The guidelines should specify the need to include the costs of in-service training and possible costs associated with replacing key scientific personnel.
- Recurrent-cost estimates should include any system-wide savings or additional costs that would be incurred as a result of the project.

- If the recurrent-cost estimates fall below those for similar projects, then they should be queried.

With respect to the last point, Heller (1991) found the net recurrent-cost ratio for a range of agricultural research and extension projects to be on the order of 0.1. In other words, the annual additional recurrent-cost obligation associated with an investment project was about 10 percent of the total cost. While such ratios will vary from countries and projects, it would be very unusual for the necessary additional recurrent costs of an "institution-building" agricultural research project to be less than 10 percent of its capital costs in any particular year.

The accurate assessment of project-related recurrent-cost requirements should trigger a form of project triage. Projects with a relatively small forecast recurrent-cost burden should then be screened on other grounds. Those with a large recurrent-cost burden should be sent back for redesign—with a reminder to the project leaders of the difficulty in sustaining high-recurrent-cost endeavors. For projects in the mid-range, the challenge would be to identify possible project modifications to reduce ongoing recurrent-cost requirements.

Incorporate recurrent-cost forecasting in program budgeting

Another way to prevent recurrent-cost imbalances is to ensure that future requirements are clearly identified in the forward budget for agricultural research. Many research systems operate on an annual budget cycle, and the recurrent requirements for the forthcoming year are only estimated with any accuracy at the end of a particular year's budget submission period. Where recurrent-cost funding requirements are likely to rise well in excess of a previous year's levels (due, for example, to rapid growth in research capacity or to an accumulation of an overhang of past recurrent spending obligations), it is imperative to forewarn financing agencies of an impending increase in requirements. Moreover, if research leaders are aware of an impending rise in recurrent-cost requirements that is unlikely to be met by traditional financing sources, they have an opportunity to alter research programs to accommodate the expected financing envelope. Medium-term forecasting of recurrent spending requirements can help to ensure such an early-warning system is in place.

Preparing medium-term forecasts is especially difficult in a volatile financial environment or in situations where medium-term research programming is not generally practiced. Even under more favorable conditions, what constitutes an "adequate" range of recurrent financing support will generally be experiment- and institute-specific. Despite the difficulties, the very process of obliging research program leaders to estimate such budget requirements helps build greater awareness of the true costs of operating the research system and of the need to plan capacity-expanding investments and operating requirements in an integrated way.

Medium-term forecasting should clearly distinguish between normal recurrent-cost requirements and those intended to address a backlog of under-funded recurrent costsoperating costs. The latter include the costs of bringing facilities up to reasonable maintenance standards, repairing equipment, and providing in-service training to familiarize researchers with recent developments in their areas of expertise. For normal recurrent-cost requirements, forecasting should clearly specify, in addition to the wage bill, the resources needed for repairs and maintenance, transport, communications, other utilities, equipment, office facilities, supplies, training, and publications.

For the first forecast year, detailed and accurate estimates of requirements will need to be made for the scrutiny of budgetary oversight authorities. For the latter years, the estimates should be indicative of the likely range of program requirements. Major assumptions should be specified, and the forecasts should be revised as program requirements change.

Strike a sustainable balance between capital and recurrent spending

If a forward estimate of the funds required to cover recurrent operating costs is well in excess of the resources likely to be available, this may signal that the research system is growing too quickly. Slowing down institutional expansion to a rate that can be effectively financed once operations are under way is one way to address the recurrent-cost problem. But this may be difficult to do, particularly if the need for new technology is perceived to be pressing, if research leaders derive greater authority from increases in staff and physical facilities, or if donors are eager to finance expansion. It would be unrealistic to expect research directors to scale back expansion plans voluntarily, particularly if recurrent-cost support is bundled together with capital investments. In such circumstances, several measures are necessary to improve the balance between capital and recurrent spending:

- A global limit on capacity-expansion investment should be established and defined by institutes, organizations, and the research system as a whole. The ceiling should be set in a way that reflects the priorities accorded to the different components of the system.
- Mechanisms should be established to monitor and enforce investment ceilings.

Ideally, those units that abide by the ceilings should be rewarded with easier access to necessary recurrent financing.

- External financing agencies should be encouraged to shift assistance efforts from institutional capacity expansion to augmenting recurrent-cost financing. They should be given assurances that this will restore a sustainable balance between capacity growth and capacity utilization.

On this last point, donor agencies may need convincing. In the past, most of them avoided financing recurrent operating expenditures on the grounds that such support would discourage countries from undertaking investments that could be sustained over time. But in the 1980s, when many countries experienced severe fiscal stress, donor support for recurrent costs became more common. This reflected not only fiscal realities—that vital institutions and assets were in danger of collapse without an injection of recurrent-cost financing—but also a growing awareness that, in many countries, utilizationcapacity utilization was as important a development goal as capacity expansion. Recent experience suggests that donors are more likely to be sympathetic to requests for recurrent-cost financing if three conditions are met. First, it must be clearly demonstrated that the support will be temporary. Second, the research system has to be willing to restructure its finances and management for increased sustainability. Third, there must be evidence that the external support will have a major impact on development.

Downsize to within the recurrent-cost carrying capacity

When all other options have been exhausted, there may be no choice but to downsize the research system to match the financial carrying capacity of the nation. In some cases, rationalizing the size and scope of the research system makes it possible to mobilize more resources. In Uganda, "right-sizing" the agricultural research system (see boxed text) stimulated an increase in research financing and the more effective use of recurrent operational resources. While the issue of right-sizing a research system is addressed at length in other parts of this book (see Chapter 5 in particular), it is important to note that a small productive research system is superior to a large inactive one.

Box 1. Uganda's NARO: The Process of "Right-Sizing" a National Agricultural Research System

In 1990, Uganda's agricultural research system was in a state of disarray. Many stations had been severely damaged during the civil war, equipment had been lost or stolen, and salaries were below subsistence requirements. Very few staff actually did any research, except under a few small projects assisted by external donors. Total agricultural research expenditures were less than one US$1 million per annum and few stations had any recurrent operating budgets at all. Generally, donors were reluctant to make commitments to the research system under such circumstances.

A strategic planning exercise was begun in 1990. It concluded that the agricultural research system should be restructured into a new, semiautonomous organization, the National Agricultural Research Organization (NARO). NARO was to retain only the essential assets of the previous research system. New management procedures were to be adopted so that NARO could focus on priority research, with sufficient resources to motivate staff and finance operations. External assistance was to be requested to rehabilitate NARO's research facilities.

NARO was officially created in 1992. Between 1992 and 1994 it absorbed parts of the existing research system, but in a manner designed to produce a cost-effective research entity with an adequate financial base. Three main cost-saving efforts were mounted. First, the 13 existing research stations were reduced to six institutions and three small specialized stations. Of the 300 variety-testing centers, only 30 were retained by research, and even these were placed under the supervision of the agricultural extension service. Second, staff

continued on next page

continued from previous page

strength was reduced from 1,520 in 1990 to 840 in 1994, with the bulk of the reductions in field worker employees and agricultural officers. Scientists were hired by NARO on the basis of a competitive screening process. A total of 167 scientists were hired by NARO compared with the 210 professionals who were on staff in 1990. Third, clear mandates were assigned to each institute and priorities were set for their key programs. On the basis of these priorities, recurrent operating costs were projected and budgets prepared for each core research program.

The restructuring was carried out by NARO's leadership in close consultation with senior representatives of the Ministry of Finance, the Public Service Commissioner, and the Ministry of Agriculture. During the restructuring, the incentives system for research staff was redesigned.

From 1990 to 1992, the highest remuneration awarded to a researcher was US$20 per month. In 1992 and 1993, a thorough review was made of the terms and conditions of employment in organizations with a legal basis similar to NARO's, such as the Bank of Uganda, the Uganda Revenue Authority, and the Coffee Development Authority. In consultation with the NARO Board, a new salary system was developed in which the minimum salary was set at US$70 per month. Scientists were to be paid between $200 and $900 per month, directors $1,100 per month, and the director general, $2,000 per month. Impressed with the reorganization of the research system, the World Bank agreed to use the proceeds of an Agricultural Research and Training Project to finance 100 percent of NARO's salary and recurrent operating costs during 1993-94 and 1994-95, and 75 percent of it for the next four years. The World Bank and other donors also agreed on an ambitious investment program aimed at rehabilitating NARO's physical facilities and equipment. By 1994, total expenditures on agricultural research had reached about $12 million per annum, of which close to $5 million was in the form of capital investment.

With donor contributions forecast to decline by the end of the decade, NARO management formulated plans for improving the organization's financial base. Commitments were obtained from the government to increase the budgetary allocation to research by 10 percent per annum, starting from a base of about $1 million in 1994. In addition, NARO was allowed to retain research cess revenues collected on coffee exports. And finally, an agreement was reached with the Ministry of Finance to enable NARO to retain revenues earned from the sale of services and research station produce. Other nontraditional forms of revenue mobilization were being explored, including the application of research cesses to other cash crops, NARO management of government commercial farms, and the establishment of an agricultural research trust fund.

Source: ISNAR, Uganda National Agricultural Research and Training Project Reports.

Downsizing, of course, has its costs too. Research capacity may be lost during the process, researcher morale may suffer, and the expenses incurred for staff severance pay and disposing of outmoded buildings and equipment may be quite significant. Clear guidelines are needed to ensure that the downsizing exercise doesn't become overly politicized and that priority activities are protected during the process.

Instill management practices aimed at appropriate use of recurrent-cost resources

Better management may be the solution to making more effective use of limited recurrent-cost resources. New management procedures may be necessary to correct problems of waste, corruption, or otherwise inefficient use of resources. The first step is to establish how, in fact, recurrent-cost resources are being used. It's unlikely that accurate records of their use will be available, particularly if dubious expenditure practices exist. What is recorded may differ markedly from what actually transpired.

Several countries have established commissions or task forces to identify measures for improving recurrent-cost management. Such bodies tend to work best when staffed with a mixture of senior research leader "insiders," presumed to be knowledgeable about the mechanics of funding within key research institutes, and those who are familiar with available options (within government, the donor community, and the private sector) to address these problems. Such advisory groups need to be provided direct access to research staff, i.e., those most familiar with the actual requirements of experiments. As management policies and procedures may be thrown into question, it is important to obtain the views of both the managers and the scientists doing the research.

While expert committees can help to unearth deficiencies in recurrent-cost management and identify strategies for improvement, there are measures that can be taken at every level of the research system:

- Individual researchers: share equipment, vehicles, and field site operations with colleagues; carefully coordinate research projects to avoid duplication and unnecessary outlays.
- Research program leader: encourage the formation of research teams to optimize use of scarce recurrent resources; reward researcher initiatives to improve use of recurrent-cost resources; identify options for interprogram sharing of facilities and other operational resources.
- Research institute leader: establish mechanisms for sharing resources—equipment, staff, vehicles—with other institutions; establish nontraditional mechanisms for mobilizing sufficient recurrent-cost resources (e.g., commercialization, sale of produce); provide clear signals to staff on management procedures for using recurrent resources and signal displeasure at ineffective or inappropriate behavior.
- Research system leader: document the extent of the recurrent-cost financing problem and forecast the shortfall; identify the causes of the problem and formulate a strategy to address the causes; involve research managers at all levels in the search for solutions; formulate the needed changes in research policy and argue the merits of these recommendations before the relevant oversight bodies.

Restore confidence in the adequacy of recurrent resources

Perceptions tend to be self-fulfilling, particularly where financing is concerned. If scientists don't believe the recurrent-funding problem has been satisfactorily resolved, they will continue to operate as if it is still a major problem. Restoring their confidence can be a real challenge, particularly if uncertain or unstable funding has plagued operations for several years.

Sharing budgetary information with scientific staff is the best way to restore their confidence. If scientists see that recurrent-cost commitments made at the time of budget approval have been honored, they will develop trust in the research system's capacity to meet essential operating needs. The watchword here is transparency—in the discussion and dissemination of financial information within the NARS.

Summary

Problems of recurrent-cost funding tend to leave research capacity underexploited. They are a long-standing source of friction between NARS and their traditional financiers, including donor agencies. The most common causes are excessive rates of investment in research capacity, poorly designed capacity-building projects, fiscal collapse, inadequate staff pay, rigidities in government budgeting and expenditure patterns, political bias against agricultural research, and weak managementfinancial management.

In extreme cases, problems of recurrent-cost funding can bring the research system to a grinding halt. More often, the system simply struggles on in a weakened state: in-service training and maintenance are neglected; trained and otherwise motivated staff leave; and the research agenda becomes biased toward projects with low recurrent costs. The research agenda may also be easily influenced by outside parties who supplement meager recurrent resources in exchange for access to a large share of the research system's "sunk-costs".

The first step in addressing the recurrent-cost issue is to identify the cause and extent of the problem. Next, research leaders should bring the problem to the attention of their main traditional financiers so that appropriate solutions can be jointly identified. Lack of sufficient recurrent-cost resources should also inspire research leaders to explore all possible nontraditional sources of research support and to seek the approval of oversight agencies to use proceeds thus gained to augment research agency budgets.

As preventative measures, new projects should be screened for their recurrent-cost implications, and forecasts of short- and medium-term recurrent-cost requirements should be built into the financial projections of research system programs. The balance between capital and recurrent spending may need to be improved. This can be done by reducing the rate of capital expansion and/or by encouraging external financiers to provide resources to augment recurrent spending requirements. In some cases, the research system may have to be downsized to fit within the country's financial carrying capacity. At the same time, options for improving the management of recurrent resources

should be reviewed. Opportunities for making more effective use of recurrent-cost operating resources exist at all levels of a research system. Finally, the confidence of the research community in the adequacy of recurrent-cost resources needs to be restored. Greater transparency in financial reporting and easier access to budgetary information are the key measures for reassuring researchers that meaningful improvements have been made.

References

Chhibber, A. and J. Khalilzadeh-Shirazi. 1991. Public Finance. In *Restructuring Economies in Distress: Policy Reform and the World Bank*. Eds. V. Thomas et al. Oxford, UK: Oxford University Press.

Heller, P. S. 1991. Operations and Maintenance. In *Public Expenditure Handbook*. Eds. K. Chuvand R. Hemming. Washington, DC: International Monetary Fund.

Howell, J., ed. 1985. costs*Recurrent Costs and Agricultural Development*. London: Overseas Development Institute.

Huffman, Wallace E. and Robert E. Evenson. 1993. *Science for Agriculture*. Ames: Iowa State University Press.

Oram, P. 1985. Agriculture Research and Extension: Issues of Public Expenditure. In *Recurrent Costs and Agricultural Development*. Ed. John Howell. London: Overseas Development Institute.

Pardey, P. and J. Roseboom. 1989. *ISNAR Agricultural Research Indicator Series*. Cambridge, UK: Cambridge University Press.

Premchand, A. 1993. *Public Expenditure Management*. Washington, DC: International Monetary Fund.

Pritchard, A. J. 1990. Lending by the World Bank for Agricultural Research: A Review of the Years 1981 through 1987. Technical Paper No. 118. Washington, DC: World Bank.

Tabor, S. and P. Ballantyne. 1995. Policy Conditionality in Agricultural Research Projects. In *Agricultural Research in an Era of Adjustment: Policies, Institutions and Progress,* Ed. Steven Tabor. Washington, DC: Economic Development Institute of the World Bank.

Recommended Reading

Howell, J., ed. 1985. *Recurrent Costs and Agricultural Development*. London: Overseas Development Institute.

This text weaves together the backdrop to the recurrent-cost problem in agricultural development, with specific cases in budgetary planning and management and a discussion of options for financing agricultural services. The text includes a review of public expenditures in research and extension, management of recurrent costs, and a number of case studies of recurrent-cost financing in a mix of African countries.

Premchand, A. 1993. *Public Expenditure Management*. Washington, DC: International Monetary Fund.

This book provides a comprehensive discussion of the public expenditure process from a management perspective. It covers a range of issues, from budget formulation to effective service delivery. Particular attention is given to the issue and consequences of insufficient recurrent-cost spending, and to the linkages between macroeconomic distress and expenditure reform. The book discusses practical options for restructuring public expenditures during periods of stress-fiscal stress.

Heller, P. S. 1991. Operations and Maintenance. In *Public Expenditure Handbook*. Eds. K. Chuvand R. Hemming. Washington, DC: International Monetary Fund.

Heller summarizes his many years of empirical research into the causes and consequences of recurrent-cost funding problems. Estimates of recurrent-cost requirements for various categories of public-sector investment are presented. Highly readable, the chapter synthesizes some of the generic causes of recurrent-cost problems and presents strategies for improving the financing and delivery of operations and maintenance services of the public sector.

Chapter 4
Remuneration Policy

Edwin G. Brush

Introduction

The capacity of a national agricultural research system to generate technology depends largely on its human resources, particularly the size of the scientific workforce and staff qualifications. Past efforts to develop research capacity have included efforts to increase the number of scientists and upgrade their qualifications. Research systems in developing countries made impressive gains between 1970 and 1990 when the number of scientists more than doubled (Pardey, Roseboom, and Anderson 1991). And today, more than half of the agricultural scientists in many developing countries hold advanced degrees (Pardey and Roseboom 1989).

However, even when there are enough qualified staff, research capacity can be undermined by unfavorable conditions of employment. Inadequate or inappropriate remuneration in some systems with well-developed human resources seriously impairs the ability of scientists to carry out their scientific mission. In some countries, scientists' earnings may not reach the level necessary to sustain their families, and incentive structures may fail to stimulate professional achievement.

Remuneration is a multifaceted, and often thorny, issue in human resource management. It involves setting the appropriate levels and components of compensation and using that compensation as a management tool to enhance productivity. Most research staff in developing countries are government employees and significant issues relating to public-sector wages have emerged in recent years. Among these are the excessive size of government wage bills, surplus government employees, the erosion of wages, and wage compression, i.e., the narrowing of wage differentials between the top and bottom levels of the staffing hierarchy (World Bank 1991). Linking remuneration to employee performance is also a significant policy issue for public-sector managers today.

This chapter is aimed at policy makers and research leaders trying to sustain the agricultural research capacity of their countries by improving remuneration conditions of research staff. These two groups often must work as partners, clarifying remuneration issues from their respective vantage points and incorporating these perspectives in policy formulation and implementation. This chapter aims to enrich their perspectives.

Policy makers and research leaders find that remuneration issues are usually interconnected. For example, there is a direct link between the size of a wage bill, even though wages may be low, and the presence of surplus employees. Furthermore, attempts by governments to stem wage erosion, tempered by social and political concerns, have led some countries to shore up wages exclusively in the lower levels, thereby reducing differentials with the top.

In considering remuneration policy, readers will recognize that there are higher-order issues for developing countries to consider as we approach the 21st century. These include defining the role of government and delineating the government's capacity to fund operations. Recent trends toward privatization embody these issues. Their resolution will affect judgments about what size of public sector is appropriate and will influence the rules that governments apply in setting wages. It will also have an impact on the overall cost of the public service and its management.

Figure 1 illustrates the relationship between the issues discussed in this chapter and other aspects of remuneration policy. While each issue is significant, we chose to concentrate on two that are clearly pressing concerns for research leaders: declining wage levels for research staff (wage erosion) and linking researchers' pay with their performance.

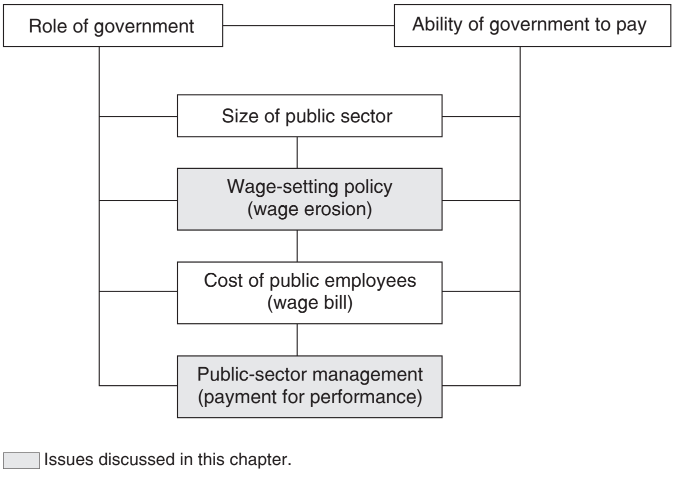


Figure 1. Major issues of remuneration policy

Wage erosion was selected as a topic because there is less discussion of it in the literature than of wage-bill size and surplus employees (see Recommended Reading). To date, more countries have taken steps to cut wage bills and reduce surplus staff than to eliminate erosion. Policy makers and research leaders ready now to tackle the wage erosion problem may therefore find our discussion useful.

The second issue, the link between pay and performance, was chosen because improving wage levels, while necessary, may be insufficient to inspire effective research activity. Performance incentives may also be needed. Many public-sector research organizations have been unable to make the link, leaving pay levels disconnected from performance. Failure to link the two deprives research systems of a useful management tool for maintaining research capacity.

Public-sector remuneration problems have been a concern in developing countries for many years and they will likely take many more to resolve. Taking a long-term perspective is therefore essential. Lessons from cross-county experience in Africa suggest that public-sector reforms may take from 15 to 25 years to bear fruit (Wescott 1994). However, in some countries, where private-sector capacity may facilitate public-sector adjustment, reform may proceed more quickly (Scott 1994).

The discussion here aims to help policy makers and research leaders to develop the necessary long-term perspective. And because circumstances will differ from country to country and require different measures, the discussion is descriptive rather than prescriptive. For each issue, we cite discussions in the literature and outline policy options that have been advanced to address it.

Following the topical discussions, the focus shifts to examples of remuneration policy experiences from developed and developing countries. The chapter concludes with a selection of recommended reading for further exploration of these and related policy issues.

Wage Erosion

Wage erosion, the loss of salary purchasing power, is an issue in public-sector organizations in much of the world: in Asia (Nunberg 1988), Latin America (Ardila, Trigo, and Piñeiro 1982; Chaudhry, Reid, and Malik 1994), and Africa (Lindauer, Meesook, and Suebsaeng 1988; Merode 1991; Adamolekun 1993). It is often cited as a problem in national agricultural research systems (Eicher 1989; Alirahman and Tabor 1993; Antholt 1993; Brush 1993; Pardey, Roseboom, and Beintema 1995).

Salaries of research staff in some countries meet only 30 percent of their basic needs (Eicher 1991). Monthly wages of public-sector employees in general have eroded to such an extent that, in many countries, they are barely adequate to cover minimal needs for even one or two weeks (Adamolekun 1993). In some countries, salaries do not even constitute a living wage (World Bank 1991; Stevens 1992).

The evidence of wage erosion in research institutes is compelling, portrayed in anecdotes by credible witnesses including senior scientists and managers. For example, a scientist from a national institute explained that his monthly salary in 1995 was equivalent to the cost of only eight bottles of local beer. In another country, a manager revealed in 1991 that his monthly salary paid for only three-days' supply of the local food staple for his family.

Origins of the problem

On the surface, wage erosion is caused by "inflation in the face of infrequent salary adjustments that have not kept up with price increases" (Lindauer, Meesook, and Suebsaeng 1988, p. 7). The result is that many public servants, including those in professional and managerial positions, "must take two, three, or even four jobs just to make ends meet" (Husain 1994, p. 10). Such moonlighting leads to chronic absenteeism. It also depresses morale. The words of one scientist capture the effect of wage erosion: "The government pretends to pay us and we pretend to work." Erosion also leads some staff to use research facilities for nonresearch tasks to boost their income. For national research systems, the combined effects of wage erosion represent a reduction in research capacity.

Wage erosion is affected by macroeconomic policies, market conditions, and wage-setting practices. Policies that have contributed to wage erosion include measures to limit general pay increases (e.g., revising inflation indexing procedures and freezing cost-of-living adjustments), individual pay increases (e.g., freezing promotions), and in-kind benefits or pay supplements (e.g., housing, family allowances, travel allowances, and overtime). These policies, sometimes implemented in structural adjustment programs, are designed more for "keeping the government wage bill in check rather than promoting reform of public pay policies to make the public sector more productive" (Schiller 1990, p. 82). Wage erosion appears to be a sacrifice made by governments to reform their economies in the face of erupting public-sector wage bills.

The fact that government employment makes up a large share of the formal (wage-earning) sector in many developing countries contributes to wage erosion. While developed countries average about 20 percent of their total employment in the public sector, the figure for many developing countries is over 50 percent and, in some cases, exceeds 80 percent (Heller and Tait 1984; Lindauer, Meesook, and Suebsaeng 1988; Mackenzie 1991).

This pattern is prevalent in agricultural research. For example, a recent survey of 17 African countries found that 90 percent of the agricultural researchers were employed in public-sector organizations (Pardey, Roseboom, and Beintema 1995). That there was little private sector activity in agricultural research implies that the public sector has "monopsony" power over the agricultural research community. A "monopsony" is said to occur when there is only one buyer for a particular good or service. Monopsony labor markets are typically low-wage (Fogel and Lewin 1974). In such a situation, there is little effective pressure to prevent wage erosion.

In many developing countries, wage-setting practices in the public sector also contribute to wage erosion. A position is assigned to a grade with a predetermined salary range based on its level of responsibility and skill requirements. No provision is made for comparing salaries with those of positions that have similar responsibilities and skill requirements in the private or nongovernmental sectors. Thus, the "*technical methodology* for assigning [wages] provides no means of assuring that salaries ... will bear a consistent relationship with the opportunity costs faced by workers" (Reid and Scott 1994, pp. 52).

In contrast, salary-setting practice in developed countries is commonly based on the "prevailing wage" principle. Government agencies are "required to pay wages comparable to those received by private employees performing similar work" (Fogel and Lewin 1974, p. 411). However, developing countries that lack a robust labor market may not be compelled to follow this principle.

Comparisons of public- and private-sector remuneration is complicated by differential nonwage benefits. Among the many benefits found in developing countries, job security is typical in public-sector employment but not in the private labor market. "Given differing degrees of job security across employer groups, complete wage parity for even similar categories of workers should neither be expected nor desired" (Lindauer, Meesook, and Suebsaeng 1988, p. 15).

Since reference is not made to private-sector wages in setting public-sector wage scales, little account is taken of the opportunity cost of skilled manpower. This failure contributes to wage erosion. In addition, even a small or emergent private labor market can effectively shut out public sector access to high-demand professionals such as accountants and computer technicians. Public organizations must often circumvent normal employment policies to attract and retain staff with such skills. However, circumvention undermines confidence in public-sector management.

Within the public sector in some countries, wage differentials can be found that seem to counter monopsony. A person employed in a favored function of government may enjoy better wages than someone else with equivalent skills who has a less favored function. This condition, known as "wage dispersion", appears to display some traits of a private labor market within government but is a result of arbitrary measures rather than opportunity-cost calculation. Wage dispersion poses problems for less favored functions that have to compete in a government labor market for high-quality staff or staff with scarce skills (Nunberg and Barbone 1994).

Even without opportunity-cost data, wage setting in the public sector tries to provide remuneration that will attract and retain qualified employees. However, donor-provided training, a widespread benefit in national research systems, may undermine the ability of public organizations to establish such wages. It is the experience of many research systems that recruits are often attracted more by training opportunities than by the wage level. After being trained, many leave for jobs in more favored functions of government, in nongovernmental organizations, or in the private sector. In this scenario, recruitment is possible but wages are insufficient to attract or retain qualified staff.

Despite concerns expressed by donors that some projects fail to build human resource capacity in public organizations, in part because of the attrition of trained staff, it is often donors themselves who poach qualified staff (Cohen 1992). Opportunity costs in domestic labor markets of developing countries are skewed by externally biased wages. Young scientists who earn US$10,000 to $15,000 per year as research assistants while studying for a PhD abroad cannot be expected to be happy about returning to $2,000-a-year jobs in their own country. The presence of externally funded positions, whether in government projects or in nongovernmental organizations, will continue to challenge the use of opportunity-cost calculations for determining public-sector wages.

Wage erosion affects the capacity of national research systems irrespective of employment alternatives. Where alternatives do exist, scientists seek them out and exploit them; attrition is their response to wage erosion. Where alternate employment isn't available—for example, if the private labor market is small—some scientists will respond to wage erosion by moonlighting in the informal (nonwage) sector. In either case, research capacity is reduced due to wage erosion.

Options for easing wage erosion

Perversely, efforts to improve public-sector remuneration in some developing countries have exacerbated wage-level problems in their national research systems. For example, where reform was intended to promote more egalitarian compensation, wages improved for lower-level staff but not for staff in higher grades. Targeting lower-income earners for increases results in wage compression, i.e., reduces the ratio between the highest and lowest salaries. Compression intensifies the effect of wage erosion at higher salary levels (Nunberg 1988). Thus, organizations with large proportions of professional staff, like national research institutes, have been hit hard by such measures.

Other efforts to ease wage erosion may also have been detrimental. This is true of certain benefits and allowances, or nonwage remuneration. A long list of nonwage components has crept into many remuneration structures. These include housing, transportation, spouse allowances, special-post allowances, pensions, position allowances, seniority payments, and leave. One African country amassed 175 nonwage components (Schiller 1990). Employees depend heavily on benefits and allowances which, for some, can exceed wages. A survey of research organizations in one Latin American country, for example, found that allowances represented 80 to 90 percent of the income of professional staff (Bennell 1989a).

Such benefits and allowances can pose problems for both staff and employers. Staff may feel there is a problem of equity in their distribution. Concerns about equal pay for equal work arise since few benefits and allowances are provided on the basis of performance (e.g., overtime pay). More likely, nonwage remuneration is awarded on the basis of function (e.g., a special-post allowance) or personal status (e.g., a spouse allowance).

Nonwage remuneration introduces rigidities into the management of the agricultural research labor force (Schiller 1990; Mackenzie and Schiff 1991; Reid and Scott 1994). These include loss of transparency in the way compensation is determined, compensation compression, and reduced capacity to pay competitive wages. These arise, in part, from difficulties in valuing benefits and allowances and in budgeting for them. Furthermore, since such benefits are probably not linked to the nature of the job or to performance, managers can't use them as a tool for encouraging efficiency.

A favored option to reform nonwage remuneration is to monetize benefits and allowances, i.e., convert them to cash that can be consolidated with the basic salary (Lindauer, Meesook, and Suebsaeng 1988; Schiller 1990; World Bank 1991; Mackenzie and Schiff 1991; Adamolekun 1993; Nunberg and Barbone 1994). The aim is to increase the share of wages in the remuneration system.

Some national research systems have sought to fight wage erosion by arranging for an semi-autonomous status that allows their wage levels to differ from those set by routine wage guidelines in the public sector. This approach may appeal to research leaders whose room to maneuver vis-à-vis wage policy is constrained by government regulations. Such an institutional status is based on arguments that agricultural science is of strategic importance to national development. However, only limited success has been obtained with this approach (Antholt 1993) and there are serious concerns about the sustainability of these arrangements.

One concern about the sustainability of autonomous institutes is the justification for granting researchers a statute different from other professionals in the public sector. This concern focuses on the strategic importance of research vis-à-vis other government functions like education, medicine, taxation, and customs. Special status for research institutes creates pressure for recognition of other functions. In some cases, such pressure has led States to dismantle special statutes. Furthermore, most cases of special status "are completely donor-driven and donor-dependent" (Dia 1993, p. 3), depending in the long run on government's ability and willingness to pay.

Technical solutions to the wage erosion problem in developing countries are elusive. By and large, where measures have been tried, they have been part of civil service reforms. These reforms are proceeding today in the context of adjustments that redefine the role of government, reduce the size of the central government, increase the private provision of goods and services, and decentralize government functions (Husain 1994). Policy makers and leaders of national research systems looking for solutions to the problem of wage erosion need to examine their options in light of the broader reforms sweeping their countries. Their challenge is "not to argue for special treatment for agricultural research, but to show a commitment to reform and high standards of performance in agricultural research, as well as in the other branches of public service" (Tabor, Quartey Papafio, and Haizel 1993, p. 7).

Pay for Performance

Wages in most national agricultural research systems are regulated by seniority; that is, increases in pay reflect cumulative years on the job. The advantages of this system are, among others, that it is transparent and easy to administer, recognizes the value of increased experience, and is not very susceptible to abuse by political pressure. Among its disadvantages are its potential to disrupt the chain-of-command structure whereby superiors earn more than subordinates and the fact that it stimulates regular growth in payroll expenses. Another weakness is that the system is not designed to help managers direct and improve performance. In fact, it may discourage top performers.

Today, research organizations are often encouraged to choose a pay system that awards increases mostly as a result of improved performance. Pay rates are determined through a competitive process in which performance is ranked and top performers compensated more than lesser performers. Among the advantages of the system are that it promotes achievement of agreed-upon objectives, encourages development of new skills, allows more control over payroll growth, helps establish performance standards and accountability mechanisms, and creates an environment that encourages all employees to do their best. The system also has several disadvantages: performance is difficult and time-consuming to measure; competition may conflict with team efforts; expectations may be raised to the point where some staff will not perform tasks without the promise of reward; the system focuses on lowest-common-denominator measures of performance; there is the potential for abuse via political pressure; some employees may see the system as unfair; and managers may assign performance ratings that are too high.

Pay for performance presents policy makers and research leaders with a set of dichotomies: single versus recurrent costs, set-aside versus derived budgets, measuring performance in terms of outputs versus behavior, and individual versus group performance. These dichotomies represent options in pay-system design, some of which are more likely to be available than others for public-sector organizations.

There are two basic approaches to paying for performance: single and recurrent. Single payment may take the form of cash awards or bonuses based on performance criteria, pay linked to volume of production, pay linked to profits from sales of goods or services, or pay linked to gains in efficiency. Recurrent payment includes promotions and salary increases based on job performance criteria or linked to the acquisition of knowledge.

In developed countries, the lump-sum bonus is the most popular performance-based reward system among private-sector organizations (McAdams 1991; Sullivan 1988), while promotion is the most common approach in public-sector organizations (Perry and Porter 1982). The latter approach, also known as merit pay, is an increase in base pay. However, in research systems in many developing countries, financial conditions have curtailed the use of promotions. Since single-payment schemes such as bonuses carry less financial obligation or risk than recurrent payments, they could be attractive to national research systems with limited resources to pay for performance.

Using promotions to reward scientific performance raises the issue of limited career opportunities in many national research systems. Often, the only path to a higher position is to abandon science for management (Brush 1993). Thus, reward may undermine research performance in the long term as key scientific talent is diverted from its central mission. A clear option for using promotion as a reward is to provide scientific staff who wish to practice their craft the same opportunity for promotion as those oriented toward management.

Parallel paths for promotion, scientific and management ladders, provide this option.

Bonuses or promotions for performance can be budgeted for via set-asides or dividends. Set-asides, or merit-pay pools, are budget resources reserved ex ante for performance-related pay. In recurrent schemes, a set-aside for performance payment this year becomes a salary obligation in succeeding years (Pearce and Perry 1983). Dividends are based on budgetary guidelines that result in payments related, for example, to savings from efficiency improvements (gain sharing) or increased sales (profit sharing). The latter is uncommon in public-sector organizations which are not profit-oriented; the use of gain-sharing is limited in public-sector organizations because budget lines are often not fungible.

The method used to appraise performance can be a major problem with pay-for-performance systems (Geis 1987; Sullivan 1988). Measurement variables are an issue, especially where "a single system for measuring and rewarding performance is applied to many employees doing different work and making different contributions to the organization" (Cumming 1988, p. 49). Even if they do not have a pay-for-performance system in place, research leaders in developing countries are familiar with the difficulties in measuring researcher performance (Bennell 1989b).

Two basic performance factors can be measured in any research system: output and behavior. Agricultural research organizations measure output in terms of research, extension, instruction, and administrative factors (Zuidema 1990). Research outputs include proposals, reports, articles, technologies, and patents. However, choosing to measure performance solely by output raises the issue of measurement validity. Many research organizations recognize that individual behavior, too, is an important factor in overall performance.

Behavior is commonly recorded in the form of personal traits. For example, the trait of "diligence" may include a set of related behaviors such as "comes to work on time;" "when at the office, works all the time;" "does not leave the office early;" and "respects regulations." Traits are popular in performance measurement systems because they apply to a wide variety of jobs and are easy to record on assessment forms. However, they are difficult to measure reliably. Thus, translating traits into specific behaviors may alleviate reliability concerns (Patten 1982).

Research organizations in developed countries commonly use combined measures of output and behavior. A survey of 20 private laboratories in the USA found that two measured only behavior, eight measured only output, and 10 measured both behavior and output (Meinhart and Pederson 1989).

Any pay-for-performance option needs to consider whose job it is to appraise performance. In general, the first-level manager, the person responsible for assigning and supervising day-to-day activities of a staff member, is the one most suited to appraise performance. In most national systems, the program manager is the first-level manager of researchers. Yet in many systems, it is the second- or even the third-level manager who is given the task of appraising scientists' performance. Increasing the input of program managers in performance appraisal can help to improve the validity of the results.

In developed countries, alternative appraisal systems are widely used in various branches of science. For researchers' performance, a familiar and successful alternative is appraisal by peers (Kane and Lawler 1978). More radical approaches have appeared recently. One is to make scientists' clients responsible for performance appraisal (Chester 1995). For agricultural researchers in particular, it has been proposed that farmers "have a significant voice in determining compensation and recognition" (Antholt 1993, p. 26).

Another issue of pay-for-performance is whether to reward individuals or groups. While pay is inevitably individual, performance-based reward systems can link an individual's remuneration to the performance of a team, department, or organization. In public-sector organizations, individual performance is more likely to be rewarded (Murlis 1987). Group-incentive plans are more common in the private sector where firms may have more flexibility to experiment with human resource management techniques. Group plans are usually based on measures of output or savings from efficiency improvements. The benefits ascribed to these plans include greater productivity, innovation, and teamwork (Scott and Cotter 1984).

In summary, the public-sector environment affects the choice of options for linking pay with performance. Lessons learned by many who have made choices in both public- and private-sector organizations include the understanding that the success of pay-for-performance schemes is conditional on various factors (Scott and Cotter 1984; Murlis 1987; Sullivan 1988; Schiller 1990; Appelbaum and Shapiro 1991). For the public-sector research, they include the following:

- the presence of a good basic salary and benefits package within the tramework of good overall personnel administration;
- the ability to give significant rewards;
- managers willing to explain and support the reward system in discussions with employees;
- agreement on performance factors that can be objectively measured using an approach that is easy to understand, operate, and monitor.

These conditions suggest that pay-for-performance schemes cannot be rushed into successful operation. Solutions to wage erosion and budget shortfalls must come first. Even with these issues taken care of, Schiller (1990) estimates that at least three years is required to implement a performance-based reward system in public-sector organizations in developing countries.

Examples of Remuneration Policy

Civil service reforms in developing countries have had mixed impacts on the pay of public employees (Merode 1991). In some cases, pay levels even decreased, signaling a failure of the reforms to solve wage erosion. In other cases, reforms had greater success. Here are some examples of countries' experience with remuneration policy for agricultural research personnel.

Indonesia (Alirahman and Tabor 1993)

Wage erosion in Indonesia's Agency for Agricultural Research and Development (AARD) was already well under way when the government implemented a structural adjustment program in 1983. The program included, among other restraints, limiting pay increases for civil servants. The result was an accelerated erosion of researchers' salaries, especially at the senior levels; this also decreased the compression ratio, the difference between the highest and lowest salaries of scientists. Between 1980 and 1990, researchers' salaries eroded by 35 to 40 percent, bringing some close to the poverty line. In this period, weakening morale, rising absenteeism, moonlighting, and increased use of research facilities for nonresearch purposes were linked to wage erosion.

In the early 1990s, the government reformed its policy for civil service remuneration to enhance the competitiveness of public-sector employment. One reform improved incentives for skilled workers, including researchers, by providing special supplements, thus bringing salaries far closer to those prevailing in the private sector. This also increased the compression ratio for wages of bottom- and top-level research staff. It signaled an understanding among policy makers of the need to maintain competitive salaries for agricultural scientists and other skilled public servants.

Ghana (Tabor, Quartey Papafio, and Haizel 1993)

In Ghana, wage erosion, currency devaluation, and structural adjustment policies that limited civil service wages combined to create a situation where the pay of agricultural scientists fell short of what was needed to meet essential living expenses in the late 1980s. As elsewhere, in Ghana this condition resulted in poor staff morale, erratic attendance at work, and the proliferation of nonresearch activities by scientists to supplement their meager salaries. They were also able to augment their salaries by participating in overseas training and conferences entailing frequent travel away from their jobs. Research capacity was severely reduced.

In 1988, the government paid a 50-percent salary bonus to researchers and other skilled public-service workers to rectify the situation. Then in 1991, the government revised remuneration policy, raising the salaries of scientists and other skilled workers by up to 300 percent. The revision specified that scientists should receive most of the increase in cash rather than as in-kind payment. At the same time, salaries were decompressed, widening the pay range between unskilled laborers and senior scientists. These revisions have attracted back many of the scientists who had left Ghana for employment abroad. Today, research leaders in Ghana are aware that challenges remain: reducing overstaffing of support personnel and actively participating in the design and monitoring of future adjustments.

Chile (Venezian and Muchnik 1994)

The Instituto Nacional de Investigaciones Agropecuarias (INIA) is a semiautonomous institute in Chile, the main component of the country's agricultural research system. From 1972 to 1990, Chile implemented a structural adjustment program aimed, in part, at reducing the size of the public sector. This had a major impact on the institute, increasing its private-sector funding of research. At the beginning of adjustment in 1972, 90 percent of INIA's budget was from public funds. By 1990, the figure had dropped to 35 percent. During this period, the number of scientists in the research system increased by 66 percent.

Staff attrition has remained low in INIA despite large and growing salary differentials between INIA and private agribusiness. This is attributed to the fact that the scientists are allowed to take on external consultancies and other part-time contracts outside the institute, and to keep a portion of the proceeds. In this way, the total income of the scientists remains competitive while they retain the benefits of being employed by INIA.

The Philippines

The research system in the Philippines, including universities and autonomous research institutes, links performance with promotion.[1] Some component entities have even developed their own methods for doing this. For example, a leading agricultural university, the University of the Philippines at Los Baños, appraises outputs and behavior of staff to provide an objective basis for granting merit promotions. To do this, the university developed an elaborate appraisal system in which staff receive points for various outputs (products from research, extension, instruction, and administration) and for behavior. Points accumulated by staff are an important factor in promotion. However, they do not lead automatically to promotion since other factors such as the availability of higher-level positions are factored into such decisions.

Philrice, a semiautonomous research institute, also links promotion and performance, but measures outputs only and in a much less formal manner. Researchers negotiate six-month performance targets with their supervisors who then rate the researchers' output against the targets. Two consecutive very high ratings are required for a researcher to be eligible for promotion. Other factors also count for promotion—for example, possession of the minimum education qualifications defined for the position. The promotion policy states that seniority will be counted only when all other factors are considered equal.

The success in the Philippines of different performance-promotion systems illustrates a lesson learned in the study of public-sector management in Latin America (Reid and Scott 1994). That is, no single design can guarantee

[1] Examples of pay for performance are more difficult to find in the public sector in developing countries than cases dealing with wage erosion.

success. Rather, the culture of the organization in which the system is embedded influences success or failure more than the system's technical design.

References

Adamolekun, L. 1993. A Note on Civil Service Personnel Policy Reform in Sub-Saharan Africa. *International Journal of Public Sector Management* 6(3):38-46.

Alirahman and S. R. Tabor. 1993. Structural Adjustment and Agricultural Research in Indonesia: The 1980s Experience. Briefing Paper No. 5. The Hague: ISNAR.

Antholt, C. A. 1993. Getting Ready for the Twenty-First Century, Technical Change and Institutional Modernization in Agriculture. World Bank Technical Paper No. 217, Asia Technical Department Series. Washington, DC: World Bank.

Appelbaum, S. H. and B. T. Shapiro. 1991. Pay for Performance: Implementation of Individual and Group Plans. *Journal of Management Development* 10(7):30-40.

Ardila, J., E. J. Trigo, and M. Piñeiro. 1982. Human Resources in Agricultural Research: Three Cases in Latin America. *Agricultural Administration* 10:213-234.

Bennell, P. 1989a. Compensation Schemes for Agricultural Researchers. In *Human Resource Management in National Agricultural Research*. Report of a Workshop, 7-11 November 1988. Pp. 212-220. The Hague: ISNAR.

Bennell, P. 1989b. Annual Performance Appraisal Schemes in Agricultural Research in Developing Countries. Working Paper No. 24. The Hague: ISNAR.

Brush, E. G. 1993. Human Resources for Agricultural Research: Issues for the 1990s. *Public Administration and Development* 13:295-305.

Chaudhry, S. A., G. J. Reid, and W. H. Malik. (eds.). 1994. *Civil Service Reform in Latin America and the Caribbean, Proceedings of a Conference*. World Bank Technical Paper No. 259. Washington, DC: World Bank

Chester, A. N. 1995. Measurement and Incentives for Central Research. *Research-Technology Management* 38(4):14-22.

Cohen, J. M. 1992. Foreign Advisors and Capacity Building: the Case of Kenya. *Public Administration and Development* 12:493-510.

Cumming, C. 1988. Linking Pay to Performance. Why is it so difficult? *Personnel Administrator* 33(5):47-52.

Dia, M. 1993. A Governance Approach to Civil Service Reform in Sub-Saharan Africa. World Bank Technical Paper No. 225, Africa Technical Department Series. Washington, DC: World Bank.

Dia, M. 1994. Civil Service Reform: The African Experience. In *Civil Service Reform in Latin America and the Caribbean, Proceedings of a Conference*. Eds. S. A Chaudhry, G. J. Reid, and W. H. Malik. World Bank Technical Paper No. 259, pp. 18-21. Washington, DC: World Bank

Eicher, C. K. 1989. Sustainable Institutions for African Agricultural Development. Working Paper No. 19. The Hague: ISNAR.

Eicher, C. K. 1991. Leading Issues in Strengthening Agricultural Research Systems in Sub-Saharan Africa. In *Enhancement of Agricultural Research in Francophone Africa*. Pp. 25-74. Nairobi: African Academy Science Publishers.

Fogel, W. and D. Lewin. 1974. Wage Determination in the Public Sector. *Industrial and Labor Relations Review* 27:410-432.

Geis, A. A. 1987. Making Merit Pay Work. *Personnel* 64(1):52-60.

Heller, P. S. and A. A. Tait 1984. Government Employment and Pay: Some International Comparisons. Occasional Paper No. 24. Washington, DC: International Monetary Fund.

Husain, S. S. 1994. Civil Service Reform and Economic Development. In *Civil Service Reform in Latin America and the Caribbean, Proceedings of a Conference*. Eds. S. A Chaudhry, G. J. Reid, and W. H. Malik. World Bank Technical Paper No. 259, pp. 9-10. Washington, DC: World Bank

Kane, J. S. and E. E. Lawler. 1978. Methods for Peer Assessment. *Psychological Bulletin* 85(3):555-586.

Lindauer, D. L., O. A. Meesook, and P. Suebsaeng. 1988. Government Wage Policy is Africa, Some Findings and Key Issues. *The World Bank Research Observer* 3(1):1-25.

Mackenzie, G. A. 1991. Public Sector Employment. In *Public Expenditure Handbook, A Guide to Public Expenditure Policy Issues in Developing Countries.* Eds. K. Chu and R. Hemming. Pp. 41-45. Government Expenditure Analysis Division, Fiscal Affairs Department. Washington, DC: International Monetary Fund.

Mackenzie, G. A. and J. Schiff. 1991. Public Sector Pay. In *Public Expenditure Handbook, A Guide to Public Expenditure Policy Issues in Developing Countries.* Eds. K. Chu and R. Hemming. Pp. 46-51. Government Expenditure Analysis Division, Fiscal Affairs Department. Washington, DC: International Monetary Fund.

McAdams, J. L. 1991. Performance-Based Reward Systems. *Canadian Business Review* 15(1):17-19.

Meinhart, W. A. and J. A. Pederson. 1989. Measuring the Performance of R&D Professionals. *Research - Technology Management* 32(4):19-21.

Merode, L. De. 1991. Civil Service Pay & Employment Reform in Africa: Selected Implementation Experiences. Institutional Development & Management Division, Division Study Paper No. 2, Africa Technical Department. Washington, DC: World Bank.

Murlis, H. 1987. Performance-Related Pay in the Public Sector. *Public Money* (March):29-32.

Nunberg, N. 1988. Public Sector Pay and Employment Reform. Public Sector Management and Private Sector Development. Working Paper WPS 113. Washington, DC: World Bank.

Nunberg, B. and L. Barbone.1994. Transforming the State: Issues in Public Administration Reform in Poland. In *Civil Service Reform in Latin America and the Caribbean, Proceedings of a Conference.* Eds. S. A. Chaudhry, G. J. Reid, and W. H. Malik. Pp. 251-280. World Bank Technical Paper No. 259. Washington, DC: World Bank.

Pardey, P. G. and J. Roseboom. 1989. ISNAR Agricultural Research Indicator Series, A Global Data Base on National Agricultural Research Systems. Cambridge, UK: Cambridge University Press.

Pardey, P. G., J. Roseboom, and J. R. Anderson. 1991. Regional Perspectives on National Agricultural Research. In *Agricultural Research Policy, International Quantitative Perspectives.* Eds. P. G. Pardey, J. Roseboom, and J. R. Anderson. Pp. 197-264. Cambridge, UK: Cambridge University Press.

Pardey, P., J. Roseboom, and N. Beintema. 1995. Agricultural Research in Africa: Three Decades of Development. Briefing Paper No. 19. The Hague: ISNAR.

Patten, T. H. 1982. A Manager's Guide to Performance Appraisal. London: The Free Press.

Pearce, J. L. and J. L. Perry. 1983. Federal Merit Pay: A Longitudinal Analysis. *Public Administration Review* 4:315-324.

Perry, J. L. and L. W. Porter. 1982. Factors Affecting the Context for Motivation in Public Organizations. *Academy of Management Review* 7(1):89-98.

Reid, G. L. and G. Scott. 1994. Public Sector Human Resource Management in Latin America and the Caribbean. In *Civil Service Reform in Latin America and the Caribbean, Proceedings of a Conference*. Eds. S. A. Chaudhry, G.J. Reid, and W. H. Malik. World Bank Technical Paper No. 259, pp. 39-81. Washington, DC: World Bank.

Schiller, C. 1990. Government Pay Policies and Structural Adjustment. *African Development Review* 2(1):81-120.

Scott, G. 1994. Strengthening Government Capacity to Manage Human Resources: The New Zealand Experience. In *Civil Service Reform in Latin America and the Caribbean, Proceedings of a Conference*. Eds. S. A. Chaudhry, G.J. Reid, and W. H. Malik. World Bank Technical Paper No. 259, pp. 172-179. Washington, DC: World Bank.

Scott, K. D. and T. Cotter. 1984. The Team That Works Together Earns Together. *Personnel Journal* 63(3):59-67.

Stevens, M. 1992. *Preparing for Civil Service Reform, a Primer.* Papers on Pay and Employment. Washington, DC: World Bank (unpublished manuscript)

Sullivan, J. F. 1988. The Future of Merit Pay Programs. *Compensation and Benefits Review* 20(3):22-30.

Tabor, S. R., H. K. Quartey Papafio, and K. A. Haizel. 1993. Ghana: Structural Adjustment and Its Impact on Agricultural Research. Briefing Paper No. 3. The Hague: ISNAR.

Venezian, E. and E. Muchnik. 1994. *Structural Adjustment and Agricultural Research in Chile*. Briefing Paper No. 9. The Hague: ISNAR.

Wescott, C. 1994. Civil Service Reform in Africa. In *Civil Service Reform in Latin America and the Caribbean, Proceedings of a Conference*. Eds. S. A. Chaudhry, G.J. Reid, and W. H. Malik. World Bank Technical Paper No. 259, pp. 217-229. Washington, DC: World Bank.

World Bank 1991. The Reform of Public Sector Management, Lessons from Experience. Country Economics Department, Policy and Research Series No. 18. Washington, DC: World Bank.

Zuidema, L. 1990. *Performance Assessment Factors for Agricultural Researchers.* ISNAR Training Series - Human Resource Management No. 14. The Hague: ISNAR.

Recommended Reading

Cascio, W. F and E. M. Awad. 1981. *Human Resource Management, an Information Systems Approach*. Reston, Virginia, USA: Reston Publishing Company, Inc.

This is a compendium of guidelines and tools for developing a human resource management system in which remuneration is a key component. It clearly presents a theoretical foundation and practical details with, for example, sample appraisal forms. It is broad enough to encompass private and public-sector organizations, but is based on developed-country experiences.

Chaudhry, S. A., G. J. Reid, and W. H. Malik (eds.). 1994. *Civil Service Reform in Latin America and the Caribbean, Proceedings of a Conference*. World Bank Technical Paper No. 259. Washington, DC: World Bank.

Recent and comprehensive, this technical paper includes detailed analyses of public-sector remuneration issues and policy reform from more than 10 countries in the region. It also gives overviews of experiences in remuneration reform from developing countries in other regions, notably Africa, as well as from developed countries in Asia, Europe, and North America. Analyses stress the practical nature of the issues although some authors present theoretical frameworks.

Dia, M. 1993. A Governance Approach to Civil Service Reform in Sub-Saharan Africa. World Bank Technical Paper No. 225, African Technical Department Series. Washington, DC: World Bank.

This publication discusses the creation of enclaves (autonomous institutes) in Africa that are exempt from civil service regulations and salary constraints. It analyzes constraints in public-sector management that affect the success of enclaves, including lack of accountability, lack of rule of law, and lack of openness and transparency. It suggests that countries with these constraints should use approaches other than enclaves to reform their civil service. It presents a scheme for sequencing reforms.

International Labour Office. 1984. *Payment By Results*. Geneva: International Labour Organization.

Lessons learned about pay for performance in developed countries are presented, but the discussion is sensitive to issues relative to developing countries. The publication includes guidelines for assessing the applicability of pay for performance schemes.

Israel, A. 1987. *Institutional Development, Incentives to Performance*. Published for The World Bank. Baltimore, Maryland, USA: Johns Hopkins University Press.

While this does not discuss remuneration *per se*, it presents a coherent conceptual framework for dealing with remuneration issues in developing countries. The framework is based on the principles of specificity and competition within organizations. For example, techniques to stimulate competition are relevant to solving wage erosion, and increasing specificity is necessary for the validity and reliability of performance measurement.

Lawler, E. E. 1981. *Pay and Organization Development*. Reading, Massachusetts, USA: Addison-Wesley Publishing Company.

This is a comprehensive look at remuneration issues by a leading scholar on compensation management. It focuses on lessons learned in developed countries, principally in private-sector organizations, and thoroughly presents issues such as motivation and compensation, performance measurement, and sequencing of remuneration reform.

Merode, L. De. 1991. Civil Service Pay & Employment Reform in Africa: Selected Implementation Experiences. Africa Technical Department, Institutional Development & Management Division Study Paper No. 2. Washington DC: World Bank.

This study paper presents case histories of three reform programs in West Africa. The programs had mixed success but the lessons learned (for example, concerning elements of success and common problems) should be useful to others planning reforms.

Mohrman, A. M., S. M Resnick-West, and E. E. Lawler. 1989. *Designing Performance Appraisal Systems, Aligning Appraisals and Organization Realities*. San Francisco, USA: Jossey-Bass Publishers.

Design considerations discussed in this work include measurement approaches, assignment of responsibility for measurement, and linking measurement and reward. Key issues such as legal constraints, evaluating professional staff, and integrating appraisal with other management systems are also discussed. The examples are from developed countries, mostly from private sector.

Osborne, D. and T. Gaebler. 1993. *Reinventing Government, How the Entrepreneurial Spirit is Transforming the Public Sector*. New York: Plume (Penguin Books USA, Ltd.)

This book provides lessons from the USA on topics such as introducing competitive practices in public-sector organizations, budgeting for performance pay, and measuring performance in government operations.

Schiller, C. 1990. Government Pay Policies and Structural Adjustment. *African Development Review* 2(1):81-120.

This is a thorough review of the issues surrounding non-wage remuneration, merit pay, and wage compression in public-sector organizations. It compares information on these topics from countries throughout sub-Saharan Africa.

Chapter 5
Coping with Fiscal Stress in Developing-Country Agricultural Research

John McIntire

Introduction

Many developing countries rapidly increased public spending on agricultural research in the 1970s and 1980s. While they did so in recognition of the need for new technologies to spur rural growth, the increased spending was sometimes unsustainable. Many "fiscal stress" problems—less nonsalary operational funding, less capital per scientist, abrupt changes in program, staff and management, and eventual disruptions in productivity—grew out of the rapid expansion of national agricultural research systems (NARS). This paper summarizes some evidence about these problems. It first defines countries in which fiscal stress occurred and then describes possible responses.

Fiscal Crisis in National Agricultural Research

A fiscal crisis in agricultural research developed during the 1980s in some LDCs. Table 1 shows that research spending fell in absolute terms in five of the 18 countries for which adequate information is available, and in per capita terms in three others (Côte d'Ivoire, Mali, and South Africa). Even where spending did not fall, it grew from a low base relative to national income.

A relevant indicator of spending is expenditures per scientist, since this measures the capacity with which scientific skills are used. Real expenditures per scientist rose slightly in 17 African countries from 1961 through 1976 but fell sharply from 1976 through 1991 (Pardey and Roseboom 1997) a pattern related to the initial development of trained scientists followed by the inability of the programs to secure funding proportionate to rising staff numbers. In Africa, the most common pattern was rapid growth in foreign financing for research in the 1970s which became unsustainable in the 1980s. Expenditures per scientist also fell in 13 Latin American countries from the period 1981-85 to 1992-93 (Echeverría, Trigo, and Byerlee 1995). No general evidence is available for Asia, but the problem seems to have been less severe there as Asian countries had much stronger economic growth in the 1980s than Latin American or African nations.

Quantitative evidence about fiscal stress and its effects on the composition of spending for salaries, operations, and capital is sparser. Limited data from Africa reveal no significant rising or falling trend in the budget shares of operations or capital from 1986 through 1991. References to the falling or low shares of nonsalary operating and capital funds are often made in World Bank documents for research projects, notably in Turkey, Indonesia, Niger, and Mexico.

There are four key points. First, national agricultural research spending did not universally decrease in the 1980s. Of the large countries in Table 1—China, India, Indonesia, Mexico, and Nigeria—spending declined only in Mexico and Nigeria, both of which suffered repeated fiscal crises in the 1980s that affected all government interventions. Second, public spending on agriculture was not more severely cut in the 1970s and 1980s, during periods of significant structural adjustment, than spending on other sectors. So the sector as a whole was not specially targeted for fiscal stringency. Third, research spending is generally a small fraction of public expenditure in developing countries—the highest level, in China,[1] was 3.5 percent of aggregate public expenditure. Current spending is therefore not generally a major burden on the budget. Fourth, macroeconomic difficulties are not the only cause of fiscal stress. Internal causes, notably overstaffing and overspending on unworthy activities, are also important, a point taken up below.

Are declines in spending related to fiscal stress?

Accelerating inflation is one index of fiscal stress, as are a rise in the public-sector deficit and an increase in the ratio of debt service to exports (Table 2). These stresses constrain the public budget, as the real value of fiscal resources erodes and as funds are diverted for debt service. About half of the countries had higher inflation in the 1980s and two-thirds saw debt service rise as a share of exports. There was a mild and negative relation between inflation and the growth of agricultural research spending; countries with lower inflation in the 1980s than in the 1970s would have spent slightly more on agricultural research than countries with higher inflation, but the effect was not very large.[2] A comparison of Tables 1 and 2 shows fiscal stress was somewhat more general than the cuts in agricultural research spending. It is not possible to conclude that fis-

1. The Chinese value may be exaggerated because some of the agricultural research institutions in that country are run like commercial businesses (Pardey, Roseboom, and Fan 1996).

2. The “mild relation” was estimated by the regression $dS = 2.605 - 0.155\ I$ ($F=2.286$, p-val $= 0.150$, $df=1,16$) where dS is the growth in real research spending in the 1980s and I is the change in inflation between the 1970s and 1980s.

cal stress automatically caused restrictions on research spending; cuts in research funding tend to have other causes.

Table 1. Some Indicators of Research Spending

	Growth of spending (%)	Spending as % of	
	1981-91[a]	All public expenditure[b]	GDP[b]
Countries with recent ISNAR indicators			
Botswana	-3.8	0.5	0.2
Burkina Faso	9.5	3.4	0.5
Colombia	-6.0	0.3	0.0
Côte d'Ivoire	0.1	1.2	0.4
Ethiopia	10.6	na	0.4
Ghana	14.4	1.3	0.3
Madagascar	8.6	1.8	0.3
Mali	0.1	2.2	0.5
Niger	3.9	1.6	0.3
Nigeria	-9.1	na	0.1
Senegal	-4.3	1.3	0.3
South Africa	1.8	0.3	0.1
Zambia	0.0	na	0.1
Zimbabwe	4.2	1.1	0.4
Other countries			
Chile	na	na	na
China	5.0	3.5	0.3
India	7.5	3.4	0.6
Indonesia	6.2	0.8	0.2
Malaysia	3.6	1.07	0.3
Mexico	-8.9	0.2	0.0

Sources: [a]From S. Tabor (1996, Table 1a) for Botswana, Burkina Faso, Côte d'Ivoire, Ghana, Ethiopia, Madagascar, Niger, Nigeria, Senegal, South Africa, Zambia, Zimbabwe; calculated by author from Mazzucato (1994, p. 31) for Mali; Echeverría, Trigo, and Byerlee (1995, p. 4) for Colombia and Mexico (1992-93); from Pardey, Roseboom, and Fan (1996, p. 16) for China, India, Indonesia, and Malaysia.
[b]Calculated by author from World Bank (1995) and from S. Tabor (1996, Table 1a) for Botswana, Burkina Faso, Côte d'Ivoire, Ghana, Ethiopia, Madagascar, Niger, Nigeria, Senegal, South Africa, Zambia, Zimbabwe; calculated by author from Mazzucato (1994, p. 31) for Mali; Echeverría, Trigo, and Byerlee (1995, p. 4) for Colombia and Mexico (1992-93); from Pardey, Roseboom, and Fan (1996, p. 16), for China, India, Indonesia, and Malaysia.

Internal causes of fiscal stress

Some fiscal stress originates within the research system itself. A prominent internal cause is spreading spending too thinly across commodities, regions, and research themes. Many poor countries feel compelled to work on all regions and on all goods, even if there is little or no expected benefit, for reasons of equity across regions or producer groups. A second internal cause is overspending on activities with low returns. Examples are agricultural mechanization, which is better done by the private sector,[3] research on biotic stresses that have little economic effect, and surveys of soils and other resources. A third cause is duplication—for example, of stations, laboratories, and other analytic facilities. Sometimes, identical scientific programs are found in different institutions.

Table 2. Some Indicators of Fiscal Stress

	Avg. annual rate of inflation (%)[a]		Public deficit (% of GDP)		Debt service (% of exports)	
	1970-80	1980-92	1980	1992	1980	1992
Countries with recent ISNAR indicators						
Botswana	11.6	12.6	0.2	-11.4	1.9	–
Burkina	8.6	3.5	0.3	na	5.9	6.2
Colombia	22.3	25.0	1.8	na	16.0	36.4
Côte d'Ivoire	13.0	1.9	11.4	3.7	38.7	31.9
Ethiopia	4.3	2.8	4.5	na	7.3	14.2
Ghana	35.2	38.7	4.2	na	13.1	26.7
Madagascar	9.9	16.4	na	5.9	17.1	18.6
Mali	9.7	3.7	4.7	na	5.1	7.4
Niger	10.9	1.7	4.8	na	21.7	14.2
Nigeria	15.2	19.4	na	na	4.2	28.9
Senegal	8.5	5.2	0.9	na	28.7	13.8
South Africa	13	14.3	2.5	4.7	na	na
Zambia	7.6	48.4	20	na	25.3	–
Zimbabwe	9.4	14.4	11.1	6.7	3.8	32.0
Other countries						
Chile	187.1	20.5	-5.6	-2.4	43.1	20.9
China	na	6.5	na	na	4.3	10.3
India	8.4	8.5	6.5	4.9	9.3	25.3
Indonesia	21.5	8.4	2.3	-0.5	13.9	32.1
Malaysia	7.3	2.0	6.2	-0.3	6.3	6.6
Mexico	18.1	62.4	3.1	-0.8	49.5	44.4

Source: World Bank.

What Can be Done?

Several relevant characteristics of developing countries constrain their reactions to funding shortfalls:

- Developing countries have little or no private research capacity to substitute for government research if public funding declines. While the low share of private research is not permanent, it is clearly linked to national

[3] Examples are efforts to develop mechanized rice transplanters, small tractors, and processing equipment, which either have never been adopted successfully, or have been bypassed by better machines from private sources.

income; very few countries with per capita income less than $1,000 have any significant private research. Umali (1992) shows that private sources finance less than 7 percent of total agricultural research in Pakistan, Bangladesh, India, and Indonesia.

- Tropical countries usually find it harder to borrow technology from abroad, thus making it difficult to substitute imported for domestic research. Shortfalls in domestic funding cannot be compensated by greater reliance on foreign science.
- These countries have large, poor farming populations. This makes it difficult to solicit research funds from farmers, even if they are ultimately the beneficiaries of research. This public finance problem means that research to benefit poor farmers must, to some extent, be subsidized by other classes, and this is politically difficult.
- Some private research financing possibilities are underexploited for legal and administrative reasons. For example, though there is significant private research financing of commodity-based institutions in Malaysia and the Philippines, in many other nations the legal framework renders private contributions to research uneconomical.

The initial reactions of most research programs are to freeze real spending or let it decline, without active steps to reduce activities. Subsequent reactions are passive reductions in spending—not replacing staff who leave, paying bills (including salaries) late, and delaying capital acquisition and training. More active reactions are to dismiss staff, eliminate activities per staff member, close stations, and sell other capital. In discussing active reactions to fiscal stress, it is first necessary to distinguish between two types of funding cuts: transitory and permanent.

A transitory shock is an annual or seasonal shortfall in funding, with no implication that it is necessarily permanent. The most common response to transitory shocks is deferment of capital expenditures; in a growing program, such actions frustrate everyone involved, but have no lasting effect.

The basic issue is not so much to eliminate short-term revenue fluctuations—they are inevitable—but to eliminate restrictions on public research managers that aggravate the effects of fluctuations. Research managers often cannot borrow from commercial banks, borrow from the government against future allocations, reallocate staff or expenses, or release staff without costly severance costs. Transitory shocks are like cash flow problems in private business and can be dealt with in the same way. The sustainable remedy for the costs of transitory shocks is therefore to allow public-sector enterprises to operate on commercial principles.

Since we do not know how much funding comes from research system earnings—such as sale of seeds, harvests, and by-products, rental of land and equipment, or employment of professional services—it is difficult to speculate about the impact of legal and administrative restrictions on such funding. But it is clear that effective responses to liquidity problems include

- freedom for research managers to borrow commercial funds against appropriate security within known limits and subject to standard audits;
- freedom to sell consultants' services;
- freedom to sell goods (e.g., harvests and crop residues) and to retain revenue from the sales;
- freedom to rent unused research land temporarily if research systems have land holdings they cannot afford to operate.

A permanent decline in funding can be more serious than annual or seasonal shortfalls. I say "can be" advisedly because a long-term decline in public funding for agricultural research is sometimes a rational response either to the falling importance of agriculture in the economy or to the growing importance of private alternatives to publicly funded research. Assuming that a permanent decline in public funds for agricultural research really is undesirable, what can be done about it? Potential responses fall into several categories: diversification of income, including aid; divestiture of certain activities; reallocation of public spending; making tradeoffs between investment and operational spending; institutional reform; institutional transformation; lower-cost technologies; and passive reactions (simply letting expenditure decline in real terms).

Income diversification

As research systems evolve, they eventually come to rely less on public funding from the central government. They begin to receive more money from State and local governments, private benevolent organizations, private companies, and producers (either individual farmers or farmer organizations). Novel funding sources include private-sector voluntary contributions stimulated through changes in tax laws, and greater cost-recovery from producers through an input tax (e.g., on land, water, fertilizer) or commodity taxes (e.g., export duties). How important are such sources now?

Information on nonpublic sources of funding in developing countries is patchy. The most comprehensive source (Pardey and Roseboom 1989) does not systematically refer to private contributions. Nor does it report the composition of public funding as revenues, directed taxes (e.g., commodity levies), earnings from the sale of goods and services, or foreign and domestic donations.

Partial information from various sources has been used in Table 3. For Asia, Pardey, Roseboom, and Fan (1996) observe that industry funding, while probably less in recent years than 40 to 50 years ago, is important in Indonesia, Malaysia, and Sri Lanka, where it supports 18 to 40 percent of agricultural research expenditures. They observe that "direct funding by government is still the most important source of funding" (p. 12).

Table 3. Composition of Agricultural Research Finance

Country/years	Shares of finance for domestic agricultural research (% of total)		
	Public	**Private domestic**	**Foreign**
Chile[a]			
1970-72 + 1980-82	80	20	
1985-87 + 1990-92	37	50	12
Indonesia[b]			
1981-82 - 1986-87	33		67
1987-88 - 1992-93	30		70
China			
1987	74		26
1993	56		44
Malaysia			
1986	46	54	
1993	45	56	
13 African countries			
average, 1986-1991	52.4	6.3	41.3

Sources: [a]Venezian and Muchnik 1995, p. 46, calculated from Table 3-5. [b]Tabor and Alirahman 1995, p. 92, Table 6-4.

For Africa, no comparable information is available. But, with the exceptions of agricultural research in South Africa and research on some export crops like tea and tobacco in East Africa, there is little nonpublic funding of agricultural research in sub-Saharan Africa. In West Africa, there is practically none.

For Latin America, there is a little more information on the share of research conducted by public institutions, universities, and the private sector, including producers' organizations. Echeverría, Trigo, and Byerlee (1995) report that the private sector provided between 6 percent (Argentina) and 43 percent (Ecuador) of research funding in the early 1990s. These shares were calculated when public research spending was depressed and may be considered high estimates.

One clear trend in research system evolution is the increase in research financing from farmers. But a universal argument against soliciting greater private funding in poor countries is that farmers cannot afford it. This is only partly true for the simple reason that farmers in some poor countries are already heavily taxed; the real issue is not the level of taxation but the ends to which tax revenues are put.

Evidence about taxation of agriculture in poor countries is abundant. Schiff and Valdes found that direct taxation was 8 percent in a sample of 17 developing nations. Pursell (1995) found significant general taxation of Indian agriculture as did Faruqee in Pakistan (1995). Many World Bank country studies have come to the same conclusion throughout Africa and Latin America. When indirect taxation, through overvalued exchange rates and industrial goods pricing, is included, then total (direct plus indirect) taxation on agriculture is even higher.

It has further been argued that farmers receive subsidies—on fertilizer, irrigation, credit, research, and extension—that compensate for direct and indirect taxation. From this starting point, additional taxation to fund research might indeed cause farmers to lose.[4] Empirical evidence on this is mixed. Schiff and Valdes (1992, p. 134-139) considered this counterargument for 14 countries, accepting it in five and rejecting it in nine. Faruqee (1995, p. 39) found that compensation for wheat, rice, and cotton (but not for sugarcane), mainly through input subsidies, was significant in Pakistan, but was too low to restore producers' incomes to those that would have prevailed at international output prices. There is another factor which, while it has not been quantified, suggests that some of the compensatory public spending for agriculture does not reach poor farmers. Much of the public spending is on input subsidies, which are not scale neutral. Scale-biased spending, especially for fertilizer, irrigation, and credit subsidies, which are often rationed to larger farmers, would not compensate poor farmers for the losses they suffer from scale-neutral commodity price taxation.

Another important kind of funding with potential for diversification is foreign aid. This is often the only source of physical capital and training funding. In 1991, for example, the average share of foreign aid in total agricultural research finance in 22 African countries was 42.5 percent and foreign contributions exceeded 65 percent in six nations (Pardey and Roseboom 1996, p. 24). It is tempting to seek more aid in times of fiscal stress; but even when aid is available, it may exacerbate fiscal problems. Hence, basic steps should always be taken to use aid more effectively before seeking new assistance. Here are some of them:

- **Do a full cost analysis of aid.** This includes projections of the multiplier effects of aid on recurrent costs and of the full costs of aid over time, even after foreign funding has been completed. For example, many foreign-funded activities require project management units and other significant local contributions that can deprive parallel national research of funds. Many aid projects continue using domestic resources long after foreign transfers are fully disbursed and this can add to fiscal stress.
- **Restrict aid to what is really needed through careful cost controls.** Aid, precisely because it is perceived to be free, is sometimes not subject to effective cost controls. Loose controls might then aggravate the problems of recurrent costs and scientists' time caused by aid.
- **Consider the costs of fund-raising.** Fund-raising consumes significant scientist time in many developed-country institutions and in some IARCs. While this is probably not yet true of developing-country research, it may be important in some instances. The point is to avoid these costs in the future by designing fiscal and management systems that

4. At least in the short run, before research benefits become available.

minimize the demands of fund-raising on scientists' time. One specific recommendation is to hire consultants to teach fund-raising to national scientists. A second is to centralize such expertise within the national program so as to better exploit funding sources and to reduce duplication in funding requests.

- **Carry out systematic ex ante evaluations of the economic returns to research supported by aid.** Much of the research supported by aid does not respond to local problems.[5] Even if aid carries no incremental fiscal costs during or after the project life, it often produces no economic benefits and hence detracts from the efficiency of national research.

Divestiture of activities

Divestiture may appear to be a promising way to save money during times of fiscal stress, but it poses several difficulties. The root problem is not so much that poor countries have little to divest, but that they have no one to divest to. The private and academic sectors are often so weak that divestiture can consist only of selling used assets, or dismissing staff, without their being used in agricultural research elsewhere. This lack of demand for research services outside the public sector is, of course, a major reason for resistance to staff cuts, even among staff with very low pay and no professional rewards.

A second problem is identifying which activities to divest. Many small countries lack the analytic accounting systems needed to identify costs of individual activities. So they are unable to estimate savings from divestiture. Even countries with good cost accounting are usually unable to calculate benefits from research projects. Even assuming that the economic and financial returns to research can be accurately estimated, practical problems remain in three areas:

- **Unprofitable activities for the public or private sector**. These are lines of research whose past or expected payoff is negative. They can be eliminated and the staff and other resources reallocated, but this approach may not save any money if public sector employment regulations forbid staff dismissals. It will make the research system more efficient—i.e., the impact per dollar spent will go up—but will not solve the liquidity problem.
- **Unprofitable activities in the public sector that could be profitable in the private sector.** These are activities in which the public sector is hampered by labor laws, procurement regulations, and legal restrictions (for example, laws against private plant breeding or private import of materials for plant breeding). Divestiture of these activities will not save any money unless public spending can be reduced.

[5] This was reflected, for example, in the opinions of scientists and administrators of eight African national programs elicited during a TAC review of CGIAR commitments in West Africa (TAC 1995).

- **Profitable activities that the public sector does not need to do (e.g., seed production, some analytic services).** The obstacle to divesting such activities is that the public sector has a financial interest in them. For example, some research activities may be financially remunerative to the NARS (notably, seed production or the commercial activities of parts of the Chinese research system), but they do not justify public support because they can be done by the private sector. Hence, they are good candidates for divestiture in an economic sense, but not in a financial one. In fact, they are the least likely activities to be divested during a fiscal crisis.

Reallocation of public spending

Reallocation of public spending is, at first glance, very promising because it is easy for agricultural research managers to claim that their work should have a greater claim on the public budget than defense or food subsidies, for example. But while the amounts of money that might be harvested from a reallocation are great, the political barriers are strong since the prospective losers from reallocation will seek to protect their interests. A rational reallocation also requires a detailed comparison of the economic benefits from various public expenditures and this is usually unavailable. Thus, research managers are often left to assert their priorities without having the empirical basis to defend them.

What is the "correct level" of finance for a NARS? A well-known rule of thumb is to allocate at least 1 percent of agricultural GDP to sectoral research. Most developing countries spend too little by that standard. This suggests a deep resistance among financial authorities to demands for more money and obliges research managers to be more creative in strengthening their institutions. There are four principal determinants of the correct level of public finance for agricultural research and they do not require reference to any ideal standard. Unfortunately, most developing-country research managers have failed to analyze them openly and clearly. The "correct" level of finance (see Chapter 1) depends on

- having detailed comparisons of returns to public investment both in agriculture and in other public sectors;
- the availability of other research, whether from the domestic private sector or from abroad, as a complement to, or a substitute for, domestic public science;
- success in matching private funds to public, because matching funds are the seed of a growing and sustainable research system;
- having a record of usable results derived from public research (since much of the resistance to calls for more funding can be directly attributed to the widespread failures of developing-country research to generate profitable technologies).

Tradeoffs between investment and operational spending

If a transitory financial shock presents a tradeoff between investment and operational spending, then it must usually be resolved by deferring investment, not by cutting spending for recurrent costs. To substitute for deferred investments in physical capital, some equipment can be rented, some services (e.g., land preparation or crop spraying) can be purchased, and existing equipment can be used more intensively. If necessary, the research system should borrow commercially or from public sources to maintain training and education for staff. Investments in human capital should not be deferred because such investments are partly irreversible—promising students abandon research careers, special complementary funding disappears, and external collaboration through technical assistance stops.

If a permanent shock, i.e., a secular decline in real research spending, presents a tradeoff between investment and operational spending, then the only resolution is a strict re-appraisal of the NARS to allow informed decisions about long-term priorities. The appropriate response to a permanent shock, with respect to physical and human capital, differs from the response to a transitory shock. Under permanent fiscal stress, investments in physical capital are usually the first to be canceled, while spending for education and training is maintained. Over the medium term, as trained staff take up their scientific positions, this response aggravates the fiscal crisis because the recurrent costs per trained staff member are higher than per unit of equipment.

Institutional reform

Funding of developing country research is, paradoxically, both too centralized and too dispersed.[6] Both characteristics result in high costs per unit of research, thus making institutions less flexible in times of fiscal stress.

Excessive centralization refers to the sources of funds: most poor countries rely on central governments and a few foreign donors. Centralization tends to repress the development of diversified sources of funding.[7] Local governments and producers' organizations operating within a centralized system have no incentive to seek additional resources on a long-term basis, either because the task is monumental (essentially, reform of the entire system of public finance) or because the short-term costs in time allocated to fund-raising are less than the benefits. Funding diversification is, in these cases, a long-term institutional challenge.

Excessive fragmentation refers to the spread of identical activities across small, inefficient institutions which draw on common funds. Such institutional dispersion may lead to high unit costs, especially in physical facilities, training,

---

6. This is largely for historical reasons. For example, specialized cash crop research institutes were often established by the colonial authorities or by comparatively wealthy growers' organizations.

7. This problem occurs throughout the public financial structures of poor countries.

administration, services (notably laboratories, station management, and biometrics), and some scientific areas, especially economics and soils, that should be used commonly by commodity programs. Further dispersion exists within unified institutes as individual commodity programs accumulate resources that are imperfectly shared.

Consolidation is the main solution in this case. The principal gains from consolidation appear to be in staff savings and in the rate of utilization of physical capital. Scientists in dispersed institutions will often work on similar, and sometimes identical, topics, and the resulting duplication could be eliminated by consolidation. A rough measure of the gains from consolidation is the number of public institutions per country—the more institutions, the greater the gains from consolidation.[8]

Institutional transformation

If divestiture is infeasible, then transforming public institutions into semi-autonomous organizations, with mixed public and private funding, can be effective. Such bodies can be established with a view to

- exempting research staff from public-sector employment rules, thus allowing the organization more freedom in setting salaries and benefits and in managing staff, to promote quality work;
- allowing research managers to use commercial financial management practices;
- isolating research programs from slow and costly public-sector procurement rules;
- setting explicit financial and performance contracts between research and the governments that provide funds;
- allowing research managers greater freedom to seek additional funds from other government levels and the private sector.

Lower-cost technologies

Lower-cost technologies are available in biotechnology and in information processing, but they will not create fiscal savings. In fact, the opposite happens—new methods and processes create learning costs (e.g., training) and subsequent operating costs (e.g., software upgrades and laboratory goods). The best proof of this is the very lack of sustainability in some LDC research systems in the 1980s and 1990s. The new technology of the recent past was the introduction of modern scientific research itself and the institutions needed to carry it out in the public sector. The initial learning and operating costs of modern science were financed largely by foreign transfers which were not sustainable because they were not matched by private financing or by the political

---

[8] Even countries with a single institution can gain from consolidation of departments within that institution.

support required to generate more domestic public funding of work begun with donor assistance.

The cost impact of new methods is noted in a review of World Bank assistance in the area of information technology. Hanna (1993) found those technologies to be highly productive in data base management (e.g., GIS applications for defining research sites), process control (e.g., managing laboratories and materials transport), and testing new products, notably in the environment. Those technologies had very attractive returns per unit cost, but required such large initial investments in equipment and training, and such high recurrent expenditures, that they did nothing to relieve fiscal stress. In some instances, if the fruits of such technologies are sold at a discount or given away, then they will aggravate fiscal stress.

Passive reactions

In dealing with funding problems, passive measures are often the sole resort of research managers because of the inflexibility of public sector staffing, procurement, and financial management rules. Typical passive steps are the use of fewer staff for the same activities, lower real salaries and benefits, and consumption of capital.

Summary and Conclusions

Some developing countries are suffering from a fiscal crisis in public agricultural research. The root of the problem is managing the transition from a small and exclusively public system to a mixed public and private system in which practically all the growth is on the private side.

Immediate steps

Allow public research to operate with commercial practices. Many countries have administrative and legal barriers to using private money for public research. Others allow very little flexibility in public-sector financial management. These obstacles can be costly by preventing research managers from resolving short-term liquidity problems. Even where there is very limited potential for private research financing, removing obstacles to sound commercial practices would make liquidity problems less bothersome.

Ensure that financial practices are consistent with novel technologies. Novel technologies in information processing[9] are usually applied with insufficient consideration to their potential for generating revenue. Even if some of the initial capital costs—in acquiring computers and laboratory equip-

9. The argument here regarding information processing would apply to biotechnology with even greater force.

ment, for example—are financed entirely with donor support, they invariably generate a later recurrent-cost burden. One way to relieve that burden is to sell more sophisticated services, especially in data base management, site prospecting, and process control, to the private sector, or to other government agencies. Where public-sector financial management regulations forbid such sales, they should be eliminated.

Allow public researchers and technicians to earn money outside their core institutions. It will be practically impossible to set special salary and benefit conditions for public-sector scientists and technicians by reference to the social good of research. Other public sector employees will insist upon the same treatment and eventually no one will get much additional compensation. The short-term solution to the problem of paying private-sector levels of compensation to public- sector employees is to allow them to do external consultancies. Such work is contracted and compensated on a market basis and hence tends to reward the best people. The conflict of interest inherent in this freedom has to be resolved by setting explicit limits on outside activities, such as those found in public organizations and universities in the developed countries.

Do not automatically seek special treatment for agricultural research. Agricultural research should not receive special protection from funding cuts for two reasons. First, there is the possible opportunity cost in terms of direct poverty-reduction measures (health, education, sanitation) and other appropriate public investments. Second, since the tendency to seek such treatment is something of an unthinking reaction of public-sector managers, it corrupts any debate about appropriate budgetary priorities and about efforts to satisfy those priorities when resources become more limited. Special fiscal treatment (e.g., VAT exemptions or tariff relief) should not be sought for the same reasons.

Examine foreign aid projects carefully. These projects often produce additional demands for recurrent costs that are met by taking money from existing research. In some cases, these additional demands are so large that marginal projects do not always produce net additional funding. Hence, it is a relatively simple step to subject all new foreign funding proposals to cash-flow analyses over an extended period to determine their net funding impact.

Use international and regional organizations more effectively. One alternative in times of fiscal stress is to rely more on the IARCs and regional organizations. In terms of research output, this has been successful but it does little to resolve fiscal stress, if that is the objective. This is because the latter have their own financial difficulties, they can contribute little anyway as a share of domestic efforts, and, most fundamentally, their work is a complement to national research, not a substitute. Use of international and regional organizations is particularly important for small countries. Through such organizations, they can share staff and facilities.

Do not react to every crisis with dramatic institutional changes. A dominant lesson from developing countries is the cost in foregone research productivity of extensive and repeated changes in institutional mandates, structures, and operations. This lesson contrasts sharply with the experience of the

USA, where institutional and financial stability over many years has helped to create a highly productive research system. Despite these lessons, there are many examples of costly institutional changes subsequent to funding difficulties that should have been avoided.

Longer-term measures

Immediate measures will have only limited impact and do little to resolve root problems. The deeper question is research efficiency—the rate at which new technologies are generated as a function of expenditures. Efficiency can only be bettered through longer-term measures requiring much greater analytic and political input, to ensure sustainable funding in a pluralistic system.

The leading example of longer-term measures is the reform of overall public spending. There are two major justifications for that reform. First, governments often support investments with negative returns, prompting fiscal transfers to sustain them. Second, governments undertake many activities that the private sector could do better, and because of poor incentives for public-sector performance, they do so at a loss. Hence, significant latent funds for agricultural research might often available if aggregate public spending could be reallocated. But tapping those funds requires approaches other than just asking the ministry of finance for more money.

Make the argument for greater spending in terms of competitiveness. Research spending in the developing countries is low compared with that in developed countries. Poor countries that underinvest in research must either import technologies or expect that they will lag rich-country competitors in productivity gains. Research managers must make this argument because it helps to refute allegations of special pleading.

Work for general fiscal reform. Management of fiscal stress in agricultural research, where it does occur, has to be seen as part of overall fiscal (i.e., tax and spending) reform. If research managers claim special treatment, without objective justification, then their efforts will fail because it is evident that managers in other public sectors will claim the same treatment.

Work to end economic discrimination against agriculture. Economic discrimination against agriculture steals some of the benefits of research. Hence, it is a logical part of the intellectual contribution of the research system to argue against such discrimination by studying its nature and magnitude. But this work demands a closer integration of economic research within NARS management and better links with universities.

Identify obstacles to new research. Many countries maintain tough barriers to private research investment in their intellectual property, technology transfer, and fiscal systems. In such countries, it is more effective to eliminate such barriers as a way of promoting a mixed public-private research system than it is to provide additional unsustainable subsidies to the existing public system. Eliminating obstacles to new research is the only long-term solution to the problem of paying private-sector wages to public-sector employees. New research employment opportunities, in the form of private companies, will eventually draw good scientists out of the public sector as salaries in the latter become uncompetitive.

Study institutional arrangements that include private research and/ or autonomous public establishments. Much of the long-term funding problem, where it really exists, stems from policy makers not being convinced of the objectivity of studies purporting to show high rates of return to research. That such studies are not fully convincing is no reason to discontinue them. Rather, they should be broadened to cover research undertaken under alternative institutional arrangements such as privatization where it is feasible, autonomous publicly funded establishments, and competitive grants.

References

Alston, J. M., G. W. Norton, and P. G. Pardey. 1995. *Science Under Scarcity.* Ithaca, USA: Cornell University Press.

Echeverría, R. G., E. J. Trigo, and D. Byerlee. 1995. Agricultural Research Finance in Latin America. Washington DC: World Bank.

Faruqee, R. 1995. Structural and Policy Reforms for Agricultural Growth: The Case of Pakistan. Washington, DC: World Bank.

Hanna, N. K. 1993. Information Technology in World Bank Lending. Technical Paper No. 206. Washington, DC: World Bank.

Pardey, P. G. and J. Roseboom. 1989. ISNAR Agricultural Research Indicator Series: A Global Data Base on National Agricultural Research Systems. Cambridge, UK: Cambridge University Press.

Schiff, M. and Alberto V. 1992. *The Political Economy of Agricultural Pricing Policy: A Synthesis of the Economics in Developing Countries.* Baltimore: Johns Hopkins University Press.

Tabor, S. R. 1996. Financing Agricultural Research: The Global Setting. (mimeo) The Hague: ISNAR.

Tabor, S. R. (ed). 1995. *Agricultural Research in an Era of Adjustment: Policies, Institutions, and Progress.* EDI Seminar Series. Washington, DC: Economic Development Institute of the World Bank, with ISNAR.

Tabor, S. R. and Alirahman. 1995. Indonesia. In *Agricultural Research in an Era of Adjustment: Policies, Institutions, and Progress.* Ed. Steven R. Tabor. EDI Seminar Series. Washington, DC: Economic Development Institute of the World Bank, with ISNAR.

Technical Advisory Committee. 1995. Review of CGIAR Commitments in West Africa.

Umali, D. 1992. Public and Private Sector Roles in Agricultural Research: Theory and Experience. Discussion Paper 176. Washington, DC: World Bank.

Umali, D. Personal communication.

Venezian, E. and E. Muchnik de Rubenstein. 1995. Chile. In *Agricultural Research in an Era of Adjustment: Policies, Institutions, and Progress.* Ed. Steven R. Tabor. EDI Seminar Series. Washington, DC: Economic Development Institute of the World Bank, with ISNAR.

World Bank. 1995. World Development Report, 1995: Workers in an Integrating World. Washington, DC: World Bank.

Chapter 6
Towards More Effective Use of External Assistance in Building Agricultural Research Systems

Derek Byerlee and Gary Alex

Introduction

Why do donors support agricultural research?

Support for building agricultural research systems has been a priority of many development assistance agencies, including bilateral and multilateral donors,[1] private agencies, and the development banks. On reflection, it isn't surprising that these agencies have given such attention to agricultural research.

First, in the 1960s, it became apparent that in low-income countries, broad-based agricultural growth could be the engine for overall economic development. Technical change in agriculture, especially in basic food crops, is now accepted as a prerequisite for rapid increases in agricultural productivity. The Green Revolution in rice and wheat in Asia and some parts of Latin American beginning in the late 1960s was a vivid demonstration of this effect.

Second, at about the same time in the 1960s, several economists began to estimate the rate of return to investments in agricultural research. These studies, which soon extended to the developing world, provided convincing evidence that investment in agricultural research paid high returns in many settings and was an outstanding investment, both for national governments and external assistance agencies.

---

1. Throughout this chapter the term "donors" is used for development assistance agencies, though it is recognized that development banks are "lenders" and some other agencies may be collaborators rather than donors per se.

Third, in the early stages of development, agricultural research systems require considerable investment in scientific skills, often through overseas postgraduate training, technical assistance in specialized fields of agricultural science, and investment in research infrastructure. The high foreign exchange costs and specialized nature of these investments made them appropriate candidates for support by donors. Although early efforts to build national agricultural research systems (NARS) were led by the Rockefeller and Ford Foundations (e.g., in Mexico and India), other donors, especially the United States Agency for International Development (USAID) and the World Bank, soon enthusiastically responded to these challenges.

Fourth, donors recognize the transferability of research findings and results across countries, both developing and developed. This makes for broad development impact of donor funds and in many cases provides benefits to the donor country's agricultural research system.

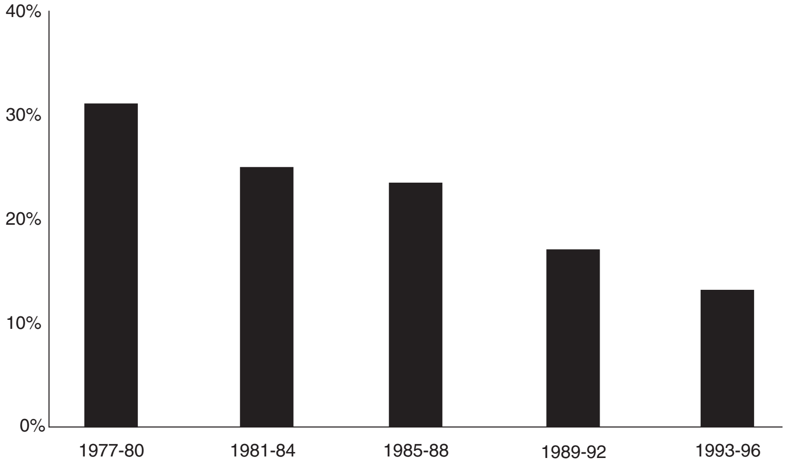
Why do countries seek donor support for research?

There are many reasons for developing countries to look to donors for financing. Simple need is often the main one. Governments may be unable (or unwilling) to provide adequate funds for agricultural research, an activity that political leaders sometimes perceive as an unreasonably long-term investment. Planning or finance ministries may also recognize that research is an attractive investment for donors and use this as an opportunity to maximize foreign assistance inflows. Within agricultural research organizations, the reasons for seeking foreign assistance may include the prestige associated with foreign-funded research work, the opportunities for more flexible management of local funds, and the attractions of foreign training and international exchanges. Evidence of high economic rates of return to research may convince national leaders and researchers of the need to maximize investments in research, whether from local or foreign sources, so as to address pressing problems of poverty, food security, and environmental conservation.

How important is donor support for national research systems?

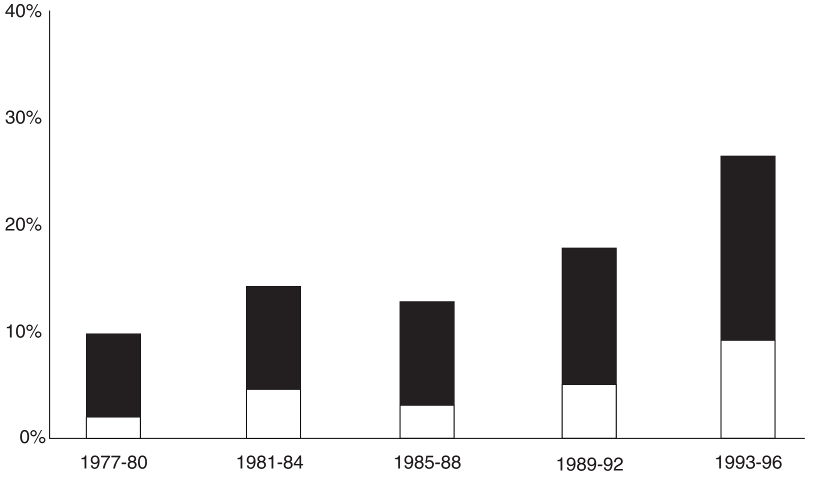
Donor support to research systems comes in many forms—grants, concessional and nonconcessional loans, technical assistance, and food aid. Although no comprehensive figures are available, by the early 1980s donors were investing over $600 million per year in agricultural research in the developing world. This amounted to 2 percent of all aid and 6 percent of aid to agriculture (Pardey, Roseboom, and Anderson 1991). Since 1980, the World Bank has been the largest "donor," contributing some $200-$350 million annually to agricultural research over the past decade or more (Pritchard 1994, Byerlee and Alex 1997). USAID has also historically been a large donor, providing $150-$200 million most years between 1980 and 1993.

No data are available on overall trends in aid to agricultural research, but using World Bank contributions as a partial guide, loans to agriculture have tended to fall in absolute terms and as a share of total lending (Figure 1). However, loans to agricultural research have fallen less than the total volume of loans to the agricultural sector, so that the share of agricultural loans going to research has increased from 4 percent in the period 1981-84 to 10 percent in 1993-96 (Figure 2).



Source: OED (1996)

Figure 1. Share of World Bank loans to agriculture



Source: OED (1996)

Figure 2. Percent of World Bank agricultural loans for research and extension

A more useful way of viewing donor support to agricultural research is by estimating the contribution by donors as a proportion of the total amount invested in agricultural research in developing countries. In the early 1980s, donors provided 16% of total public investment in agricultural research in the developing world (Pardey et al. 1991). Including donors' contribution to international agricultural research centers and networks would raise this amount to about 23 percent. However, dependence on donor support varied from virtually zero in a few countries to over 70 percent of the research budget in some countries. Using the same source, the donor share of investment in agricultural research was highest in Africa (35 percent of total investments) followed by Asia (26 percent), West Asia and North Africa (11 percent), and Latin America (7 percent). In general, donor dependence is highest in smaller countries, many of which are struggling to develop their NARS. However, donor support has historically been very high in some large countries, such as Indonesia where it averaged over 50 percent for several years in the 1980s.

Table 1. Share of World Bank Loans to Agricultural Research (%)

Region	**1981-84**	**1993-96**
South Asia	15	27
East Asia and Pacific	39	9
Middle East/North Africa and Europe/Central Asia	4	6
Latin America and Caribbean	36	8
Africa	6	50
Total	*100*	*100*

Since the early 1980s, by far the largest increase in donor funding for research has occurred in sub-Saharan Africa. Using World Bank loans as a guide (Table 1), Africa's share of total loans for agricultural research increased from 6 percent in 1981-84 to 50 percent in 1993-96, while the share to East Asia and Latin America dropped sharply (World Bank 1996). Not surprisingly, dependence on donors for funding of agricultural research is currently highest in sub-Saharan Africa, where the donor share has grown from 34 percent to 43 percent over the short period 1986 to 1992 (Pardey et al. 1997). Including the contributions to the international agricultural research centers working in Africa, the total share of funds provided externally is over 60 percent. In a sample of 23 African countries, Pardey et al. (1995) found that 10 countries funded more than half of their research from external sources. In general, donor contributions have increased during the period of structural adjustment when domestic funds have become scarcer due to tightening of budgets to eliminate fiscal deficits.

Issues: Pitfalls in Donor Assistance

It is clear that donors can make important contributions to building agricultural research systems. In view of the critical role of research in stimulating overall agricultural and economic growth, as well as the substantial component of foreign exchange and specialized skills involved, donor assistance to agricultural research should continue to be a priority for overall support to a country's development efforts. However, donor assistance to agricultural research has not always met expectations, and the challenge to future aid effectiveness will be in avoiding the following pitfalls.

Donor dependency

The first question that arises is whether donor support provides new resources for research or whether it simply substitutes for domestic funds that would have been available anyhow. Indeed, it may be argued that, given the high priority donors have assigned to agricultural research, it is often easier for a research manager to obtain funds from external sources than to fight budgetary battles with ministries of finance and the legislature. For NARS, a potential negative consequence of depending on external support for a large share of their budget is that they will fail to develop the political and grassroots support for agricultural research from their main constituency, the farmers. Longer-term financial sustainability cannot be achieved unless domestic political support for financing an increasing share of the research budget from domestic sources is developed. Certainly, **any country that finances one-third or more of its research from development assistance over a decade or more is likely to be caught in a cycle of donor dependence**. Donor assistance today will require assistance in the future to sustain the same level of research.

Fragmentation and lack of continuity of research efforts

Donor projects usually bring with them some definition of research priorities or other influence on the content of research programs. While this may be beneficial, it can also have negative effects. Donors often have their own research priorities defined in terms of commodities, problems, or geographical regions, and their assistance is often tied to these themes. Various donors have not done a good job of coordinating their efforts in agricultural research. And they frequently work with different implementing agencies or in different regions of a country. This can lead to duplication of effort and lack of support for other potentially high-priority activities. At the same time, NARS have often not had the managerial capacity to define national priorities and to absorb aid in a coordinated way that fits the needs of the country. Even when priorities are well defined, NARS that depend heavily on donors may not be in a good bargaining position to negotiate with donors to ensure that assistance fits those priorities. **Donor assistance, then, has often resulted in the fragmentation of research systems, with lack of coordination between projects; compe-**

tition between projects for scarce local funds, staff, and recognition; financing of some low-priority activities; and neglect of some high-priority activities. This can lead to a ragged system of uncoordinated free-standing projects at the periphery without a central core of high-priority research (A. Spurling, pers. comm.).

In many countries, donor contributions to research projects, as well as local financial contributions, are effectively outside the control of national research managers. Sometimes, they are not even included in national research budgets. Thus, financial coordination as well as technical coordination of research becomes a problem. Few NARS have the managerial capacity to absorb large amounts of external assistance under donors' administrative regulations. Donor-funded projects are often more successful in leveraging local funds than are national research managers, so that one commonly finds enclaves of well-funded research within a research system that is otherwise marked by an acute shortage of operating funds. This may lead to morale problems among staff not involved in donor-funded projects.

Donor projects are typically funded for specified periods of three to seven years. This introduces a lack of continuity with much of the initial year lost to start-up and the last years to planning for phase-out or extension. The relatively short time horizon of projects frequently means that equipment arrives, facilities are finished, or staff return from training only as the project is coming to an end. Technical assistance assignments are short and research programs are disrupted when funding is terminated.

Continuity is further damaged, as donors typically have pet research interests or approaches that are in vogue for a few years and that are then supplanted by the next "fad." Since most donors follow the same fads, this leads to cycles of boom and bust in research funding for some activities. For example, commodity research on staple food crops in the 1970s was replaced in the late 1970s and early 1980s by a new pet area for donor assistance, farming systems research. This in turn was replaced by research in natural resource management in the late 1980s and 1990s. (There are also fads in institutional and funding arrangements for programs or projects. Autonomous research councils, private foundations, and competitive research grant programs are examples of approaches that at certain times have been favored by donors.) While these areas of research program emphasis have strong intrinsic merits, the problem has been the tendency for all donors to jump on the same bandwagon and fund the new areas at the same time, while neglecting other critical programs. This leads to distortions in research priorities in NARS that are heavily dependent on donor financing. For example, the impact of farming systems research and natural resource management has often been limited due to lack of support from strong commodity research programs that have lost favor among donors.

The problem of "counterpart" funding

An additional problem for overly dependent countries is that **donor support often leads to rapid and unplanned growth of the NARS**. External assistance for agricultural research has traditionally been used to finance the foreign exchange component of agricultural research, such as capital equipment, technical assistance, and foreign training, while the project agreement has required the recipient to provide local currency support for remaining items. This approach has two problems. First, governments have often made commitments of local funds that they have been unable to honor during project implementation. This leads to difficulties in meeting project objectives. In recent years, with budgetary tightening under structural adjustment and policy reforms, this problem has become more severe. Second, donor assistance, by emphasizing investment in research and human infrastructure, has generally resulted in rapid expansion of the research system. At the end of the project, the additional local funds required to maintain the new research infrastructure are often not available.

Recently, to get around the problem of lack of counterpart funds for project implementation, donors have been paying an increasing share of operating budgets. In some cases, they have even paid salaries of research staff. This has been justified in part by the fact that all agriculture research is an investment, so no distinction need be made between capital and recurrent costs. While argument has some validity and is tempting to donors who want to see their projects succeed, it only shifts the problem of scarce counterpart funding to the end of the project, when research activities funded by the project must be absorbed in the local budget.

This problem of financial sustainability is particularly critical in agricultural research. Many research programs, such as plant breeding, are long-term and continuous in nature; they cannot be turned off and on according to the availability of funds without seriously undermining the achievements of research. There is no easy answer to the problem of sustainable financing, though this needs to be considered in funding any research project.

Poor utilization of costly donor-funded inputs

Much of the external support provided over the past three decades—as much as one-third of total funding—has gone to technical assistance, especially in Africa. This is important to long-term capacity- and institution-building, to developing international linkages and new perspectives in the research system, and to maintaining donor confidence and commitment. Effective technical assistance figured prominently in the "success stories" recorded at the end of this chapter. While technical assistance can provide valuable support in building research capacity, its overall record has been very mixed.

In many donor-assisted projects, large teams of technical advisers have been funded by the project. Fielding a large number of expatriate advisers is not only expensive, it can also lead to the development of an enclave within the research system and inhibit the emergence of local leadership. Many technical advisers have been assigned for a short period of two to three years and leave just at a point when they are "getting their feet on the ground." In addition, recipient countries have had little influence on the choice of technical specialists and their terms of reference. The overall result is that the quality and length of service of advisers have often been traded off for quantity, with the technical assistance then having little impact.

Overseas training is another costly component of many agricultural research projects. It is probably the most important contribution of research projects, as this provides the basis for a sustainable technology system. However, training has not always been well planned to provide NARS with a good balance in scientific skills. Staff have frequently returned from training to be placed in positions where they were unable to apply their new skills and knowledge. With the likelihood of reduced funding in the future, it is important to use the most cost-effective means to provide trained scientific staff.

Some donor-funded projects have also suffered from excessive funding. Project budgets are inflated for donors' own reasons or to provide facilities and funding requested by different agencies within the host-country government. The resulting large projects can become problems in themselves, with projects funding excess capacity. In addition, focusing on "spending the money" distracts attention from the technical content of research, and the project may end up looking "bad" if expenditure rates are low.

Inappropriate policies

Finally, government policies on prices, subsidies, and input supply often restrict efficient operation of research programs and limit farm-level productivity increases made possible by research. Such policy constraints should not, however, preclude investment in agricultural science. Research is a long-term investment that will not normally have an impact until well after a donor-funded project is completed, when the policy environment is unknown. There are good examples (such as that in Ghana described at the end of this chapter) where research was initiated in a seemingly unfavorable policy situation, but later had large impacts due to a change in the policy environment. In addition, donor assistance in recent years has focused on providing support to policy reform, which should increase future payoffs to technology generation.

Options for More Effective Aid

Despite the many potential problems of donor support to agricultural research, it is extremely important that such assistance continue. Donors can inject vital resources into agricultural research at critical periods to provide high and sustainable payoffs. Research ultimately benefits immensely from the international exchange of ideas, techniques, and inventions. Furthermore, issues addressed through agricultural research, such as food security, poverty, and environmental conservation, all have global dimensions.

Donors and country officials need to assess carefully the rationale behind proposals for research assistance. Approval should be conditional on affirmative answers to the following three questions. First, does the research respond to national development strategies and objectives? Second, over and above the support that donors and research agencies may declare for the proposals, do stakeholders such as farmers, agribusiness, and consumers also support the proposed research efforts? And third, will the assistance contribute additional capacity and comparative advantages to the research system? Assuming the answer is yes to these questions, options outlined in this section can provide guidance for using donor assistance more effectively.

Provide and coordinate donor support within the context of a strategic plan

As a critical prerequisite for more effective use of external assistance in building agricultural research capacity, **NARS must have a well-defined strategic vision for the evolution of the overall research system.** It should be presented in a relatively brief strategy document outlining the country's changing technology needs and evolving roles of the private sector, universities, and federal and state institutions in addressing such needs. The NARS should also give particular attention to sustainable support by diversifying funding sources and setting up the required funding mechanisms. Within the context of a strategic vision of the overall research system, **each national research institute or organization should have a medium-term plan that defines research priorities and the development of research infrastructure and human resources**. Such a plan can be relatively detailed but it should be simple enough that it can be updated regularly (perhaps every two to five years) without this process becoming an administrative burden.

These strategies and plans must be "home-grown." In other words, the objectives of the research system and the analysis of how these objectives will be met should originate within the country, based on consultation with a broad range of "stakeholders," especially farmers, agribusiness, and agricultural policy makers. Planning and finance ministries and donors must also be brought into the process.

Since such strategies and plans are increasingly a condition of donor assistance, it is tempting to get technical assistance specialists to do the lion's share of the work in preparing them. However, this approach may not allow for a level of stakeholder participation sufficient to build local political support for agricultural research. As stakeholders, donors should of course be consulted in preparing such plans, and it is certainly legitimate for NARS to draw on technical assistance for specific analytical skills needed in plan preparation. Donors should agree to accept the resulting priorities as the basis for their future support to agricultural research. Research managers must be strong administrators and develop strategies to deflect offers of donor support that do not fit priorities.

Research plans provide a way for donor support to be coordinated and managed by the NARS themselves. A first priority is to avoid duplication of donor efforts. But coordination can go further, as donors often have different comparative advantages in terms of the support they can provide for operational costs, training, or technical assistance. Frequently, bilateral donor support —in the form of grant assistance, for example—can be obtained for technical assistance, small and innovative pilot activities, and training. Multilateral development banks, however, are often better able to fund larger-scale programs and high-cost items.

In response to the crises facing agricultural research funding, donors have taken some potentially useful steps to coordinate their assistance. The World Bank took the lead in establishing the Special Program for African Agricultural Research (SPAAR) in 1985. More recently, it formed the Office for Agricultural Research and Extension (ESDAR), which serves as a multidonor forum for coordinating and improving the effectiveness of funding for agricultural research and extension. **The additional attention that donors themselves are giving to the coordination of assistance is welcome. Within a given country, however, the ultimate responsibility for donor coordination necessarily lies with NARS managers.**

Provide for long-term support

Numerous examples indicate that the most successful donor support to agricultural research is often long-term, covering periods of 10 to 20 years, with each successive project building on the previous. The role of external assistance evolves to meet changing needs, with local scientists being trained and progressively replacing expatriate technical assistance. One particularly useful tool is an overall financial plan specifying gradual increases in host-government funding as the donor's share of the research budget steadily declines.

Build financial sustainability

Donors should support, wherever possible, ways to diversify funding for agricultural research and to establish sustainable financing mechanisms. To this end, donor assistance might emphasize measures to promote joint ventures with the private sector, contributions from farmers and farmer associations for research, and the establishment of endowments to provide longer-term funding.

NARS expansion should generally be limited to a program size that can be supported when donor assistance ends. If this isn't possible, there may be a need to separate "temporary" programs that depend on donor support, from a "core" research program that can and will be supported beyond the period of donor involvement.

An equally important, and even longer-term, response to the dependency problem is to **develop local political support and appreciation of the benefits of agricultural research.** Building a domestic political constituency for research is a major responsibility of research program leaders in all countries, and of donors. Donor support for strengthening services to farmer associations and other clients, publicizing studies of research program impacts, and conducting seminars for policy makers on research policy and impacts are some of the ways to build political support aimed at securing stable, sustainable funding for research. Linking research to practical problems and responding to client interests are also keys to developing the necessary constituency of supporters.

Promote more effective use of currently available resources

In the past, both donors and recipients have focused external support on expansion of the research system. Clearly, the major priority of many systems today is to find ways to use available financial, physical, and human resources more effectively. External assistance can be used in various ways to facilitate this process. This may entail organizational changes but, more important, **the development of strategic partnerships and integration of a variety of institutions into a more active research system can provide significant research efficiencies.**

For example, many NARS are centered on a public-sector research institute and do not effectively integrate universities and other potential participants in the research system. Thus, an important pool of scientific talent is left untapped. In many countries, competitive grants have been set up with donor assistance to provide funding for scientists throughout the system, especially in universities. Donor assistance can also be used to facilitate linkages with the private sector, through the establishment of an appropriate legal framework for private R&D as well as joint ventures between the public and private sectors.

Many NARS are also facing difficult decisions on restructuring, which in many cases imply reductions in staff, closing of research stations or laboratories, raising salaries of remaining staff to competitive levels, and increasing operating budgets for remaining staff. But changes like these often demand additional resources, at least in the short run, for such expenditures as indemnification of released staff. Donors can help here by providing some of the flexible resources needed for restructuring and for rehabilitating existing research infrastructure to increase the productivity of remaining staff.

NARS can also increase efficiencies by judicious use of international sources of technology. Again, donors can assist by supporting the formulation and implementation of appropriate policy and regulatory regimes, as well as by providing resources for international scientific exchanges. Such linkages are important in fostering the exchange of ideas and providing adequate recognition of research work. They also encourage professionalism and world-class science, and reduce costs through collaborative work. Linkages with IARCs and advanced research institutions benefit both parties and are increasingly seen as partnerships, not one-sided assistance relationships. The challenge to donor agencies and NARS is to develop mechanisms that foster lasting partnerships —ones that will outlive individual projects.

Finally, regional agricultural research associations and networks provide another option for donors to channel assistance to NARS programs in a cost-effective manner. However, regional associations should continue to be controlled by the NARS and not become dependent on donors. Furthermore, they should retain their facilitation role and not turn into a new layer of bureaucracy between donors and NARS.

Revise priorities for external assistance funds

It is clear from the discussion above that donor assistance will be used differently in the future than in the past, when one of its main aims was to finance the expansion of the physical infrastructure that underpins research. Upgrading human resources, also a major focus of past assistance, will continue to be an important area of donor investment. However, **in the future greater emphasis must be given to developing human resources on the home turf**. Graduate research training in industrialized countries now costs about $40,000 per annum and is usually several times the cost of training in the recipient country. There will always be a need to send some researchers abroad for advanced training, especially in rapidly changing areas of science. However, past donor support to NARS has paid too little attention to building capacity in local universities. Donors might also explore options for promoting partnerships—for example, through funding of university sabbatical leaves and other exchanges.

While externally funded projects now place less emphasis on building new research infrastructure, this item cannot be completely ignored. The rapidly changing nature of agricultural science inevitably makes research skills and facilities obsolete. For example, the growing role of modern biotechnology requires NARS to update their physical and human resources so that at least a basic infrastructure is in place for testing and adapting newly available products. This is an area where external assistance can be especially critical, not only in providing resources but also in facilitating links to the global scientific community.

Many recent externally funded research projects have been caught in a dilemma: whether to make long-term investments, like rehabilitating research infrastructure, or investments with a shorter-term payoff, like providing competitive funding. While competitive funding has many advantages in ensuring that existing research capacity is effectively utilized, donor support is probably better used for developing human capital and research infrastructure necessary for long-term programs.

The role of donor support is clear in financing and restructuring research systems, rehabilitating research infrastructure, and developing human resources. The question of donor funding to cover operating costs and even salaries, however, remains a thorny issue. In the short run, it is tempting for the donor and recipient to use external funds for operating costs to prevent these from becoming a major constraint on research productivity. **The key issue is**

not whether to fund capital or operating costs, but whether external assistance is used to help build mechanisms for long-term financial sustainability.

Carefully manage technical assistance

Recognizing both the value and high costs involved, both donors and NARS must rationalize the use of technical assistance. Projects might profitably emphasize the use of a small number of high-quality, experienced scientists and managers who will serve the project over a period of five years or more, while also providing opportunities for young scientists to work in international agriculture.

NARS managers must become much more proactive in managing technical assistance. In some cases, this task is assigned very low priority. Consequently, the fielding of technical assistance personnel suffers delays and is not properly planned. In particular, NARS leaders need to be more involved in recruiting technical advisers. The selection process should adhere to standard recruiting procedures, including short-listing of suitable candidates, obtaining letters of reference, and conducting in-country interviews prior to appointment. Terms of reference for resident technical assistance personnel need to be developed collaboratively with emphasis on ensuring that planned assignments are reasonable, that necessary support services and facilities are available, that technical contributions are emphasized in the work plan, and that assignments maximize collaborative work with national staff. Administrative responsibilities should be assigned to local staff wherever possible.

Link external assistance to policy and institutional reform

The policy environment for agriculture and agribusiness should be of concern to research managers because it influences not only how well a NARS functions, but also how effectively the technology it generates can be used. An understanding of policy constraints should inform decisions on research planning, institutional reforms, and evaluation of research program impacts.

Recognizing the importance of institutional and policy reforms in making research systems more effective, some donors, especially development banks, have given considerable attention to policy conditionality in their loans. Loans for research projects may require a wide range of reforms, from changes in management and financial accounting to more drastic institutional change (Tabor and Ballantyne 1995). Such conditions are not always successful, partly because it is often difficult to plan effective institutional reform, and partly because of the way such reforms are identified. It is essential for borrowing countries to have "ownership' of institutional and policy reforms and that these changes not be seen as having been imposed from outside. This implies the need for key policy makers to support reforms openly. Local support can be facilitated by having a research and analysis capacity in the NARS to backstop policy reform. It also requires that donor agency staff devote sufficient—and often considerable— time and effort to building the commitment of local leaders to the needed reforms.

Under the right circumstances, building policy conditionality into external assistance can be very useful in reinforcing change. In some cases, external assistance agencies may be in a better position than the NARS leadership to communicate with a wide range of stakeholders in the agricultural sector. Significant reform frequently requires the concurrence and participation of stakeholders outside the ministry of agriculture, who are often more effective and better disposed to promote reform than are institutions more closely connected with current agricultural research programs (e.g., increased communication with the ministry of finance regarding research funding).

Develop strong NARS leadership and management

Many of the suggestions in this chapter imply the need for strong NARS leadership, especially in formulating a vision of the research system and articulating priorities to donors and governments. A variety of management skills and tools are also needed to ensure both effective use of donor assistance and accountability. Well-managed accounting systems with transparent financial procedures can avoid problems of duplicate administration that arise in many NARS because donors require their funds to be managed according to their own government's accounting procedures. In addition, donors are becoming more demanding in documenting results from investments. This is requiring NARS leaders to devote more attention to monitoring the performance and impact of research so that they qualify for continued donor funding. In recent years, leadership training and research management have received greater attention from many donors. Indeed, these are areas of human capacity building that warrant further support under donor assistance programs.

Success Stories of Donor Assistance

The Rockefeller Foundation in India

The experience of the Rockefeller Foundation in India is now almost four decades old, but it provides many valuable lessons for external assistance to research today (Lele and Goldsmith 1989). The Foundation's support to research was initiated in the 1950s and extended through the 1960s, when it had a major impact through its involvement in introducing high-yielding varieties of rice and wheat, which spearheaded the Green Revolution. Several elements from both the donor's side and the recipient's side contributed to the success of this program (Lele and Goldsmith 1989).

- The Foundation program was small. The number of technical advisers was kept to less than 10, and major efforts were made to recruit scientists of stature and experience who would be resident in India for at least five years. Only a small proportion of the budget was used to build research infrastructure.

- The program was well-focused, emphasizing only a few cropping systems and regions.
- The Foundation sustained support for the program over a period of almost two decades with a coherent and consistent message.
- The Indian government provided top-level political support to the program and was willing to make hard decisions when needed. The program originated from India's own perceived need for help rather than from the donor's initiative.
- The program was involved in upgrading several interrelated factors simultaneously, including scientist training and the reorganization of the research system. However, it did not create any new institutions.
- The program emphasized "borrowing" of technologies and scientific knowledge from abroad for adaptation to local conditions, rather than beginning from scratch.
- There was a strong component of human capital development, including graduate education both at home and abroad.

While in hindsight there have been some criticisms of the program (e.g., accentuation of regional inequalities by focusing on high-potential regions), it undoubtedly responded to the urgent need of the day, namely to increase food production rapidly. India's subsequent successes in bolstering food grain production can be traced, at least in part, to the base laid by this program.

Ghana Grain-Legume Development Project

The Grain-Legume Development Project (GLDP) began in Ghana in 1979 with funding from the Canadian International Development Agency (CIDA). The project aimed to support research and technology transfer to increase the output of maize and cowpeas. Technical assistance for the project was provided by the International Maize and Wheat Improvement Center (CIMMYT) in Mexico and the International Institute of Tropical Agriculture (IITA) in Nigeria. For most of the project, only one expatriate scientist was posted to Ghana, usually for a period of at least five years.

The CIDA funding provided support for rehabilitation of the research infrastructure, human resources development, and technical assistance. It was complemented by considerable appropriations by the Ghanaian government to support operating budgets for on-station and on-farm research.

The project emphasized the development of well-adapted varieties and a widely tested package of management practices for each of the major agroecological regions of Ghana. It also had a substantial technology-transfer component, later complemented by other donor-supported extension projects, including the Sasakawa Global 2000 project.

An important feature of the GLDP has been the long-term support over 17 years by both the donor agency and the Government of Ghana. By 1987, the project was already showing considerable impact. A high proportion of farmers in selected areas had adopted the improved varieties and some of the recommended management practices. By 1990, with the help of the large-scale extension program of G2000, over half of the maize farmers in Ghana had adopted some elements of the technology. Similar success has been registered in the 1990s with cowpeas. A well-trained team of Ghanaian scientists (several with PhDs) now leads the grain and legume research programs.

Although the GLDP has clearly been one of the real success stories of donor support to agricultural research in Africa, it has not been without its problems, especially as it seeks to achieve long-term sustainability after the project ends. Maize and cowpeas have clearly been favored by research funding, including local funding, at the expense of other important crops. Local funding has also bypassed the main budgetary process of the research system leading to potential problems of financial sustainability after project completion.

The SPAAR consolidated funding mechanism in Africa

Most African countries depend heavily on donor assistance for agricultural research, but this support is often poorly coordinated and integrated. Many donors are active in this area. Each typically concentrates resources on a particular region or crop. This leads to the emergence of virtually autonomous research programs, often with different approaches and priorities and with minimal coordination with research in other regions. One reason SPAAR was established was to address these problems.

SPAAR seeks to revitalize agricultural research in African NARS through regional frameworks for action based on a set of principles, including the following:

- institutionalizing participatory strategic planning;
- developing sustainable financing mechanisms;
- improving institutional structures to enhance efficiencies;
- building country-level support groups;
- strengthening linkages with the clients of research;
- promoting regional and international collaboration.

An important aspect of the strategy is the consolidation of funding behind an agreed-upon research plan.

Tanzania is one country in which a pilot program for consolidated research has been set up. Supported through the World Bank-assisted National Agriculture and Livestock Research Project (NALRP), parts of which are also financed by other donors, the Government of Tanzania has moved to implement the "Framework for Action" principles. To this end, 11 donors are collaborating to support Tanzanian research programs. Actions to date include

- development of a National Agricultural Research Master Plan;
- improvements in accounting and monitoring systems;
- establishment of an Agricultural Research Fund, which supports operating costs of collaborative research in universities and other institutions;

- enhancing sustainable financing by instituting commodity levies to fund research and by establishing research station "self-help funds" to utilize station-generated funds;
- planning an integrated information and communication system to support the research scientists;
- planning for "right-sizing" the research establishment, delegating a degree of autonomy to regional research centers, and improving incentives to research scientists.

Under this consolidated funding approach, combined donor efforts support priority research programs, as well as the Agricultural Research Fund which provides competitive research grants. Pooling of funding in a common account would be an option, but is not necessary to address the problems of effective use of donor funding. The key to success is for the NARS to make management improvements and align donor resources in ways consistent with the priorities spelled out in the national research plan.

References

Byerlee, D. and G. Alex. 1998. *Strategic National Agricultural Research Systems: Selected Issues and Good Practice*. Environmentally and Socially Sustainable Development Studies and Monographs No. 24. Washington, DC: World Bank.

Lele, U., and A. A. Goldsmith. 1989. The Development of National Agricultural Research Capacity: India's Experience with the Rockefeller Foundation and Its Significance for Africa. *Economic Development and Cultural Change* 37(2):305-343.

Pardey, P. G., J. Roseboom, and J. R. Anderson. 1991. Topical Perspectives on National Agricultural Research. In *Agricultural Research Policy: International Quantitative Perspectives*. Eds. P. G. Pardey, J. Roseboom, and J. R. Anderson. Cambridge, UK: Cambridge University Press.

Pardey, P. G., J. Roseboom, and N. M. Beintema. 1997. Investments in African Agricultural Research. *World Development* 25(3):409-423.

Pritchard, A. J. 1994. World Bank Investment in Agricultural Research Policy and Strategy: Past and Future. In *Agricultural Technology: Policy Issues for the International Community*. Ed. J. R. Anderson. Pp. 45-58. Wallingford, UK: CAB International.

Tabor, S. and P. Ballantyne. 1995. Policy Conditionality in Agricultural Research Projects. In *Agricultural Research in an Era of Adjustment: Policies, Institutions, and Progress*. Ed. S. R. Tabor. EDI Seminar Series. Washington, DC: Economic Development Institute of the World Bank, with ISNAR.

World Bank. 1996. Achievements in Development of National Agricultural Research Systems. Draft paper, Operations Evaluation Department. Washington, DC: World Bank.

Recommended Reading

Braun von, J., R. F. Hopkins, D. Puetz, and R. Pandya-Lorch. 1993. *Aid to Agriculture: Reversing the Decline*. Food Policy Report. Washington, DC: International Food Policy Research Institute.

Eicher, C. K. 1992. Building African Scientific Capacity for Agricultural Development. *Agricultural Economics* 4(2):117-143.

Echeverría, R. G., E. I. Trigo, and D. Byerlee. 1996. *Institutional Change and Effective Financing of Agricultural Research in Latin America*. Washington, DC: Inter-American Development Bank and World Bank.

Maredia, M. K., D. Boughton, J. A. Howard, D. Karanja, M. Collion, O. Niangado, and T. Bedingar. 1996. No Short Cuts to Progress: Case Studies of the Status and Impact of Strategic Agricultural Research Planning in Africa. Draft paper, Michigan State University.

Purcell, D. L. 1994. The World Bank Experience with NARS-Building. In *Agricultural Technology: Policy Issues for the International Community.* Ed. J. R. Anderson. Pp. 149-161. Wallingford, UK: CAB International.

World Bank. 1995. The SPAAR Consolidated Mechanism Concept Takes Shape in Zambia. Africa Technical Dept. Washington, DC: World Bank.

Chapter 7
Financing Agricultural Research: Do Organization and Structure Make a Difference?

Howard Elliott

Introduction

Financial crisis often triggers the restructuring of a national agricultural research system (NARS). This raises a serious question for all involved in research funding: What is the link between effective financing of research, the structure of research systems, and the organization of research activities? Clearly, where macroeconomic adjustment brings changes in the size, scope, and priorities of the research system, restructuring is often needed to put the new agenda into place. But executing research is just one among many management functions. Building and maintaining links with policy makers and securing adequate and sustainable resources for the research program are also critical tasks that can be improved through close attention to structure and organization of the research system and its component organizations.

This chapter argues three key points. First, research systems have often been structured with special attention to securing or retaining funding from governments, donors, own sources, and clients of research. Second, structures that seem highly suited to obtaining funding may not be the best ones for executing research, maintaining client support and addressing national goals. As a result, funding sustainability may be compromised. Third, specific funding mechanisms that work in one context may not transplant well to other countries, regions, or commodities. The chapter draws some lessons from NARS' experiences in Latin America and Africa, demonstrating how attention to proper organization and structure can improve both the financing and effectiveness of research.

Framework for Analysis and Definition of Terms

This chapter documents the role that organizational factors have played in sustainable financing and shows how the options available to research leaders and policy makers may be limited by particular circumstances. It also suggests alternative strategies for research leaders who must deal with the issue of sustainable financing. First, however, it is useful to set out a framework of analysis based on a systems approach.

Systems and subsystems

The starting point is that we are dealing with a system, in this case a NARS. A system is defined first and foremost by its objective — that is, it is a set of parts coordinated to achieve a common objective. A system can further be described by its environment, components, resources, and mechanisms for managing its activities (Churchman 1979). By definition, a system has interconnected parts and no independent subsystems are possible. If a system is disassembled, the essential properties of the parts and of the whole are lost, because the system is not just a sum of the parts but a product of their interactions.

A given organization might, therefore, be considered part of the NARS or part of its environment, depending on the degree to which it focuses on the common system objective and its resources are coordinated to that end. "Open systems" exchange information and resources with their environments.

There may exist a hierarchy of systems and subsystems. In the case of agricultural R&D, we may define an agricultural technology system (ATS), concerned with production, dissemination, and adoption of new technology and with marketing the output (Elliott 1990). Subsumed within the ATS may be the NARS, which, for some purposes, will include parts of the higher education system (e.g., university-based agricultural research). However, it is clear that universities belong principally to another system, the higher education system, and intersect with the NARS as part of the ATS. Here we focus on the NARS in a broader sense, which does include some parts of the higher education system. The NARS may also have subsystems at the provincial and local levels with specific planning and funding mechanisms.

ISNAR defines a NARS as "comprising all a country's entities responsible for organizing, coordinating, or executing research that contributes explicitly to the development of its agriculture and the maintenance of its natural resource base" (ISNAR 1992). The NARS may include, therefore, government institutions, parastatals, private-sector research entities, and universities. When the environment or the objective of the system changes, the components, mechanisms, and resources may also change.

Organization and structure

Sachdeva (1990) provides definitions of organization and structure that are useful for the rest of the discussion:

- *Organization and structure* refer to the institutional arrangements and mechanisms for mobilizing human, physical, financial, and information resources at all levels of the research system.
- An *organization* is a coalition of interest groups, sharing a common resource base and depending on a larger environment for its legitimacy and development. It is characterized by decision making (such as in the area of resource allocation, monitoring, and control). The organizational factor refers to how a system and its components interact with its environment and each other at all levels.
- *Structure* is determined by the way work is divided into tasks and coordinated to achieve stable patterns of behavior and output. Key aspects of structure include the size of the research system, the number and types of research institutes, the institutes' responsibilities and mandates, the system's communication and collaboration patterns, and the internal organization of research within individual institutes and experiment stations. Structure refers to how the "hardware" of the system is put together.

The design of appropriate structures for the system and the internal organization of research aim to achieve a good fit with the environment. In case studies below, we look at how responsive various structures are to clients and stakeholders, how effective they are at generating research results, and how they contribute to securing resources for research. As the environment for research changes, the system may adapt, it may change its environment, or both. If it chooses to adapt, it may change its structure, make its existing structures operate in different ways, or may add or subtract from its array of functions. There is no single, ideal structural model. Rather, different models have different strengths and weaknesses in performing certain functions in given circumstances.

Evolution of Structures and Financial Sustainability in Latin America

In this section, we draw lessons from experience in Latin America. The evolution of research systems from ministries, to autonomous institutes, to research foundations, and now to experiments with more "corporate" structures reflects their adaptation to their external environment. NARS typically attempt to incorporate new entities as new strategies become important to securing financing.

Autonomous institute model

Single, autonomous national institutes are associated particularly with Latin America, where they were the most common model from the 1960s to the 1980s. Some observers refer to them as "INIAs," from the Spanish acronym for national agricultural research institute. In most cases, these institutes were created with strong donor support and designed to liberate research from the bureaucracy and employment practices imposed by governing ministries.

Autonomous national institutes had distinct structural advantages over the ministerial units they replaced. Their directors could interact face to face with the minister and donors rather than having to plod through a hierarchy of department heads, division directors, and deputy ministers. And thanks to external resources, they were able to gain some elbow room in hiring, firing, and setting wages. In these ways, autonomous institutes were structurally and organizationally linked to their key funding sources, both domestic and foreign.

But these institutes also harbored a major weakness: they were alienated from their clients in both agenda-setting and funding, and this projected an image of nonperformance. Although their boards typically included representatives from public-sector agricultural agencies, independence from ministerial structures made other publicly funded organizations envious of their special status and resources. Thus, it was more difficult for them to find financial help later when external funding began to dry up and government budgets came under pressure.

As Echeverría et al (1996) say:

> "It is clear that declining support for the INIAs reflects in part disillusionment by policy makers with the performance of the public sector research monopoly (the INIAs) in effectively meeting today's research challenges. Thus part akers of the solution to the funding problem will be through reforms to the traditional INIA model of agricultural research to make it attractive for governments, farmers and the private sector to invest in agricultural research. This requires smaller, more flexible, and decentralized INIAs, with cost-effective and client-driven structures. They will have to be able to diversify their sources of funding away from annual government appropriations."

The single, autonomous institute model, in its particular context, represented an important institutional innovation. If a country decides to follow the model, the lessons for sustainability are:

- Avoid orientation to a single source of funding.
- Maintain links with domestic clients and political bases.
- Open the system to stakeholder pressure.

The attempt to deal with such issues showed up in the form of another structural model, research foundations.

Research foundation model

The attempt to find innovative approaches to research in Latin America led to the creation of a number of research "foundations." There were some elements of faith in their creation. First, it was believed this model would make national research more responsive to client demand and its behavior more like that of the private sector. Second, the architects of these foundations thought that governance by a mixture of private-sector, farmer, and public representatives would increase accountability and stimulate client and stakeholder interest in financing research. It should be noted that the creation of these foundations took place at a time when their principal source of funding (U.S. PL-480 and ESF programs) had "privatization" as a watchword. Despite this philosophy and the "private" designation, most foundations were in fact created with public money, whether foreign or domestic (Sarles 1990).

The pertinent elements of these foundations were as follows:

- a majority of board members drawn from outside the public sector;
- private-sector advisory groups;
- grants conditioned by contributions from the private sector;
- funds reserved for collaborative activities with other actors (universities, extension, and farmers' associations);
- competitive financing;
- deposits of funds in special accounts of the foundation instead of in the national treasury;
- tax credits for voluntary contributions to the foundation;
- apolitical management (selection of the director by an autonomous board and recruitment on professional merit).

The experience of the early foundations brought a number of sustainability problems to light:

- They began to compete with and demoralize the institutes they were expected to reinforce.
- They depended on human resources located in the national institutes.
- They were as dispersed in their activities as the public-sector institutes had been.
- To guarantee their funding they became as dependent on the wishes of donors as the institutes they replaced.
- With their higher salaries, they drew off the best human resources from the public institutes and became a parallel program.

Four important lessons have been drawn from the foundation model experience by Byrnes and Corning (1993):

- Donors (USAID) underestimated the effort (time, money, and strategy) needed to make the foundations sustainable.
- To make an institution sustainable, more attention had to be given to internal management, and client orientation was essential.

- Developing a sustainable capacity to generate and transfer technology requires client participation in setting the research agenda and at least a partial contribution to financing.
- The responsibility for allocating resources must remain with the authorities of the organization. Micromanagement by the governing body (the board) or the donor can undermine sustainability. An organization deprived of the right to fail is prevented from succeeding.

A more "corporate" philosophy underpinned subsequent attempts at structural change aimed at opening up the research system and attracting new investors. The Brazilian Corporation for Agricultural Research (EMBRAPA) was a pioneer in this corporative approach following its creation in 1973. However, we will draw on the recent case of Colombia's CORPOICA which mixes a corporative approach with notions of social control of research.

Colombia: broadening the base of ownership and financing

The Corporación Colombiana de Investigación Agropecuaria (CORPOICA) was created in 1993 as part of the restructuring of the Colombian Institute for Agricultural Research (ICA) and the Program of Modernization of the state (Chaparro 1994). Although the base of experience is too recent for definitive conclusions to be drawn, the philosophy behind CORPOICA and the attempts to develop broad-based participation in governance and financing merit discussion.

The emergence of a research corporation like CORPOICA presupposes certain prior developments: the growing importance of the private sector, the increasing sophistication of farmers and their professional organization in farmers unions or commodity growers' associations, and the declining share of small and resource-poor farmers in production and total population. These are all conditions that prevailed in Colombia on the eve of CORPOICA's creation.

CORPOICA was created as a mixed corporation operating under laws governing private sector entities. Local government, the central government, and the private sector are all investors in the research institute. The State has a clear role and financial presence, but other economic and social actors are members by virtue of paying subscriptions. Stakeholder representation is assured on the institute's board, in national plenary meetings, and at the regional and local committee level. CORPOICA documents underline the need to achieve the efficiency and rationality of the private sector, but with "social control" of research (Chaparro 1994).

This new institutional model adopted by agricultural research in Colombia has two particularly important and complementary aspects: it links the private sector to public-sector management and it promotes the diversification of funding sources. Financing for CORPOICA will come from the national budget, earned income, development project funds, membership contributions, contracts, cofinancing of collaborative research and technology transfer and international technical cooperation. State funding should provide a basis for increasing support from other sources, particularly through collaborative research. This will be encouraged through tax incentives, provision of parafiscal commodity funds and intellectual property legislation. For this to work, institutional innovation in many parts of the research system will be needed.

It is still too early to say whether CORPOICA has opened up the research system sufficiently to stakeholder management to ensure responsiveness to clients and to guarantee financial sustainability through stakeholder contributions and investment. Some critics are concerned that the private sector's demands for services are growing faster than their contributions as shareholders. However, the system's openness may eventually represent a new paradigm of stakeholder ownership in agricultural research — one in which the willingness of groups to help finance research is linked to their participation in decision making and setting the research agenda.

Institutional Change in Africa

In this section we draw selectively on African experiences to illustrate how organization and structure have played a vital role in agricultural research financing.

Tanzania: decentralization and devolution to the private sector

In the late 1980s, Tanzania reversed the usual pattern of structural change. Rather than create a parastatal institute out of research units located in various ministries, the government brought semiautonomous parastatal bodies back under its direct control, under the Department of Research and Training (DRT) of the Ministry of Agriculture and Cooperatives. The change was associated with a major national agricultural and livestock research project (NARL) supported by the World Bank and several bilateral donors. Its aim was to rationalize the research infrastructure, improve coordination of programs, and establish a single apex of accountability.

While DRT is the lead research institution, the Tanzania NARS also includes the Tropical Pesticides Research Institute, the universities, and a number of public and parapublic research bodies working on specific commodities like tea, sugar, barley, and maize. These other components of the NARS have a relationship with DRT that centers largely around the annual budget approval. However, to varying degrees, they also maintain collaborative research links with the Department.

The government has not met its commitments to maintain nonsalary operating costs in real terms. As a result, donor funding has come to provide the bulk of actual research financing. Donor contributions now account for more than 75 percent of recurrent and development budgets for research (Shao 1996).

Three structural changes are being discussed in the context of a second phase of the NARL: decentralization of research planning and execution to the zonal level; creation of a national agricultural research council (NARC) with statutory powers; and devolution of research to commodity interests as in the case of tea (DRT and ISNAR 1997).

A series of workshops at the zonal level identified regional priorities. Increased authority at the zonal level, in order to manage agricultural research according to client needs, will require strengthening the Zonal Agricultural Research Advisory Committees (DRT and ISNAR 1997). However, since donor funding is concentrated at the national level, it will also mean reinforcing internal processes for allocating and managing funds among the regions and for ensuring accountability to donors at the central level.

The second major discussion centers on the creation of a NARC with statutory powers to formulate agricultural research policy, approve programs and resources, and make funding recommendations to the minister. The creation of such a national council would effectively establish a parastatal-like apex for the research system. Enabling legislation for the creation of a NARC, as of late 1997, is still pending.

The third issue is the devolution of certain research activities to the private sector. As an example, we highlight the case of tea research (Harrison 1996), responsibility for which lies with one private and three public institutes. For many years growers have paid a cess to the Tanzania Tea Association (TTA), a proportion of which was earmarked for research. However, the TTA has not played an effective role in research and extension. Thus, neither private growers nor smallholders have benefitted from the cess, and the larger private growers have funded private research at high cost. In addition, neither TTA nor the government has been able to provide the necessary funds for the three government tea research stations to carry on complementary work in parallel with the private station.

The solution recommended by the Tanzanian tea industry is to set up an autonomous tea research institute. Both the tea industry and the government would be represented on the board and the new institute would be responsible for all tea research in the country, funded by a portion of the cess currently being paid to TTA. Initially, this was proposed at 1.5 percent of proceeds from sales (Harrison 1996).

The proposal has support in many quarters. However, there is still some opposition to the general idea of devolving control and financing of research in major subsectors to the private sector. Some key political figures stress the public goods nature of research, as well as the need for public funding and control of it even though the government may not be in a position to provide the necessary resources (Kasaka 1997). The debate centers on several issues. Would an autonomous tea research institute increase the level of resources invested in the subsector? Would the governance mechanisms ensure that both smallholders and large-scale commercial producers benefit? Would it weaken research in the remaining public-sector institutes through isolation? Are there other formulas, such as contracting services from the public sector, that could meet the industry's needs while strengthening DRT? (Shao 1996.)

The relevant question is the degree to which decentralization and devolution are driven by funding needs. The overriding factor is the dependence of the public research in DRT on donor funds. DRT functions as a policy apex ensuring effective structural links to the source of funding. Further empowerment of the technical structures at the zonal level requires strengthening of the administrative and financial infrastructure (including that of the banking system) if decentralization is to be effective. While decentralizing research makes for more effective programs, donors demand accountability at the central level. This requires appropriate mechanisms for DRT to play its role as an apex body.

In the case of key commercial crops like tea, research will need to be accountable to the producers who are supplying the funding. When the government devolves both the resources from the cess and the responsibility for research it may increase both the level of investment and the effectiveness of research. This need not break links to the public system. The private sector can contract research services from DRT institutes. Moreover, the government can influence the private research behavior through policies and any role it retains in setting the rate of the cess. This can be done on the basis of policies and contracts without requiring a formal structural link to the public sector.

Zimbabwe and South Africa: policy makers and paying clients

Both Zimbabwe and South Africa have built up impressive research capacity and recorded major achievements over the past 30 years. These have largely benefitted large-scale commercial farmers. In recent years, though, both countries have attempted to restructure their research systems and reorient their programs to better meet the needs of communal areas and "emerging" farmers. In this section, we look at how their NARS have been restructured to strike a balance between the concerns of policy makers, the needs of farmers of various types, and the interests of other important stakeholders. In managing these competing demands, the two systems have faced (or created) different problems for their own sustainability. The following paragraphs compare and contrast the two research systems and interpret organizational and structural issues as they relate to financing.

Zimbabwe's Department of Research and Specialist Services (DRSS) was created in 1948. It has primary responsibility for generating new agricultural technologies, providing support services (such as land use planning and plant protection), and performing certain regulatory functions (such as control of the dairy industry and phytosanitary and seed certification). In 1992, it held about half the country's full-time equivalent (FTE) researchers (Roseboom et al. 1995).

Commercial farmers have historically had an important role in setting research priorities. In 1970, the government established the Agricultural Research Council (ARC) as an advisory body. Five of its 12 members were representatives of commercial farmers' associations. In 1975 ARC gained more direct control when the government provided it with a grant of public funds earmarked for the activities of DRSS and the Institute of Agricultural Engineering (Roseboom et al 1995).

ARC (1995) describes the history and evolution of the Zimbabwean system as follows:

> "Prior to Independence, the focus was on the large scale commercial sector and DRSS was highly successful, as evidenced by the spectacular increase in crop yields and livestock production over the last 50 years. This success was achieved because government provided adequate and consistent financial support in real terms. Second, DRSS had operational flexibility in the management of research funds through the Agricultural Research Council (ARC). Thirdly, the human resource base was strong because DRSS was able to develop and retain top-notch scientists by offering adequate rewards and operating resources to run research programs. This gave continuity to both short and long-term research and services."

After Zimbabwe's independence, the government returned ARC to its advisory role. This reduced the influence of the commercial farmers in setting the research agenda of DRSS.

> "After independence, the mandate of DRSS was expanded to focus on the small farm sector which had been neglected in the past. Initially DRSS responded positively to this mandate as indicated by the 20 percent shift by 1986/87 in research effort and 50 percent in recurrent expenditures towards the small farm sector" (ARC 1995).

Recognizing the shift in priorities, the Commercial Oilseeds Producers' Association and the Commercial Grain Producers' Association created their own Agricultural Research Trust (ART) in 1982. They were later joined by cereal and cattle producers. The ART Farm remains a small organization with only three FTE researchers. It is funded by the associations and operates outside government control and objectives.

Since 1982, government took direct responsibility for the management of research funding which previously was the responsibility of the ARC. This change has been accompanied by deterioration in government support to DRSS. Since independence:

- There has been a 35 percent decline in the real value of government resources devoted to research.
- The proportion of total recurrent expenditure devoted to salaries has increased from 50 percent to 70 percent.
- About 21 percent of recurrent expenditure is committed to overheads, leaving only 9 percent for actual research.
- Capital development expenditure has also declined considerably, the latest (1994/95) allocation being the lowest ever and only 5 percent of the Department's requirements (ARC 1995).

There have been several proposals for dealing with the crisis: greater autonomy for DRSS while remaining within the ministry, increased cost recovery from the sale of services and products, greater government support for basic salary and overhead costs, and incentives for high-level performance by scientists. Belief that DRSS can engage in production activities to finance research goes against experience in other countries where such activities have often been a net drain on the budget and diverted attention from research. Granting more autonomy to DRSS and decentralizing financing and decision making to the Department would bring revenue collection and service provision closer in line.

The director of DRSS notes that greater stakeholder involvement is essential:

> "At a recent workshop . . . small scale farmers had promised to fund research but only if it provided sustainable solutions to problems such as soil erosion, deforestation, drought and environmental degradation. The farmers had made it clear that they wanted a tripartite relationship, with research, extension and farmers at ground level, and not with researchers exercising remote control" (ISNAR 1995).

The role of ARC is currently being debated. Should it become an effective apex body with authority to allocate research funds earned by the system? Or should it remain an advisory body and facilitator of dialogue among actors in the system?

We can see the links between structure and financing in the Zimbabwean NARS. Policymakers have oriented the system toward solving the problems of resource-poor farmers and conducting research in difficult environments, an activity that cannot be put on a cost-recovery basis. Meanwhile, the large-scale commercial sector has made provisions to satisfy certain of its needs outside the public sector and is willing to pay for other services provided by public research. External funding from the World Bank will provide basic support to DRSS to ensure its public-good role, but with attention to increased cost recovery wherever possible. There is much agreement that research should remain within the ministry in the form of a more autonomous DRSS. However, a stronger coordinating and policy-making apex may be needed — one which bridges the two types of clients and three types of finance.

We now turn to the case of South Africa, which has gone through several major structural changes since the late 1950s.

Commissions established under the South Africa Act of 1910 made interventions in agriculture the responsibility of the central government. From 1910 to 1958, the Department of Agriculture (DOA) assumed responsibility for agricultural education and technical support through 18 divisions and five colleges. In 1958, the DOA was split into the Department of Agricultural Technical Services (DATS) and the Department of Agricultural Economics and Marketing (DAEM). In 1962, DATS was reorganized further to create the Directorate of Agricultural Research (DAR) and the Directorate of Agricultural Field Services (DAFS). The roots of the present system have been described by Roseboom et al. (1995):

> "DAR was given responsibility for 10 research institutes and DAFS for three service divisions. The regional services were not affected by this reorganization and continued to control the agricultural experiment stations and colleges located throughout seven agroecological regions. Agricultural re-

search at the regional level continued to be strongly linked to extension and education and was more adaptive in character, while agricultural research at the national level under DAR did more upstream research. Links between the two levels of research were maintained, among other things, by outposting researchers from national research institutes to the regional experiment stations."

A significant reorganization took place in 1985 with the creation of two departments: the Department of Agricultural Development (DAD) and a "general affairs" department (the Department of Agriculture). DAD concentrated mainly on agricultural production, research, and extension. It continued directing its services to the white farming community. The departments of agriculture in the 10 homelands and self-governing territories did virtually no research. As Roseboom et al. (1996) note, "This meant that as a practical matter nearly all of South Africa's agricultural research was now explicitly targeted toward the problems confronting 'white commercial agriculture'."

In 1992, most of the agricultural research activities under DAD were transferred to the newly created Agricultural Research Council (ARC). Many of the agricultural research activities at the regional level, however, remained within DAD. These regional agricultural research activities were consolidated into seven Agricultural Development Institutes (ADIs) which now provide an integrated program of agricultural research, extension, training, and other services.

ARC is the principal agricultural research entity in the country. It oversees 12 agricultural research institutes, a network of experimental farms, and a staff of over 4,000, including 672 professional researchers (Roseboom et al. 1995). Table 1 outlines ARC's policy for funding projects and services.

Table 1. Income Sources for Projects and Services in South Africa

Type of project/services	Source of income
Demand-driven research needed by commercial agriculture	ARC 70% Client 30%
Mandated priorities of national State departments, e.g., natural resources	ARC 70% National department 30%
Mandated specific priorities of provincial departments	ARC 70% Provincial department 30%
Strategic projects (development of expertise and genetic resources, new activities)	ARC and/or relevant government departments
Small-scale agriculture organizations	ARC, government and donor
Consultations, other industries	100% external funding
Projects beyond borders	100% external funding

Source: Roseboom et. al. 1995.

In implementing this strategy, ARC faces several difficulties:

- **Mandate.** In the past ARC institutes focused exclusively on white commercial agriculture. Its current mandate spans the spectrum from providing strategic research to serving the entire farming community. This community now includes subsistence farmers in the former homelands, "emerging" farmers, and the commercial farmers it customarily served.
- **Budget.** When ARC left the Ministry of Agriculture, it took with it a budget allocation for its core activities and a commitment to earn at least 30 percent of its needed resources. However, concentration on farmers and sectors capable of paying the needed 30 percent means that its core support comes under fire for failing to deal with the subsistence and "emerging" farmers. The ADIs have not yet provided an effective demand for strategic services and the ability of ARC to get cost recovery from the subsistence and emerging farmers is limited.
- **Structure.** An official policy of decentralization in the Ministry of Agriculture should put resources at the regional level. Much will depend on the way the ADIs develop as autonomous regional entities or as part of a coordinated federal-provincial structure. Their relationship with ARC may develop into a coordinated one with funding allocated at both levels or the relationship may be one of applied institutes contracting basic and strategic research from a different level.

The interaction between financing and structure is strong. In the absence of a clear policy on the goals and structure of a national system, and without the necessary investment of resources to unify the various parts, the regions, ARC, and the national departments may evolve along separate paths.

Summary and Conclusions

This paper has addressed the issue of effective financing of agricultural research by linking funding to the research system's "fit" within its political and economic environment. It argues that sustainable funding can be positively affected by the ability of the system to influence its policy environment or to adapt itself to work within the established environment. Some measure of each may be necessary to ensure the political and financial support to achieve their research objectives. In adapting to their environment, systems may change their structures, ask structures to perform different tasks, or change the internal organization of the system. The cases discussed in this chapter have illustrated the different ways research systems have adjusted to their changing environment.

The evolution of Latin American NARS is marked by structural change as a response to their external environment and to internal dynamics. The move of research out of ministries to autonomous national institutes sought several things: entrée at a high political level, direct negotiations with external sources of finance, autonomy in the hiring and management of personnel, and freedom from bureaucratic regulations. Experience shows that such autonomy depended crucially on government sources of finance supplemented by one key donor and tended to insulate the national institutes from stakeholder control. An essential weakness of the State itself, then, was responsible for this weakness in autonomous institutes.

In the 1980s, the move to create demand-driven research led to the growth of "private-sector" alternatives to the national institute model in the form of foundations. This coincided with a privatization philosophy in a key bilateral donor, although funding came largely from government and external public sources (food aid and economic support funds). Private-sector representation on foundation boards brought a certain group of stakeholder interests to the table. However, it may also have led to a dispersion of effort and did not eliminate the orientation towards donor agendas. Internal mechanisms for allocating resources, managing research, and determining the focus of accountability proved to be the weaknesses of the foundations.

The development of private-sector research and a more "corporate" form of organization among the stronger research systems was one response to the weak national institutes and their monopoly on research. The foundations created structures for allocating essentially public money. As research and other services became more pluralistic, attention focused on creating structures to bring research closer to its clients and on mechanisms for having clients provide funding for research. Structures that promoted ownership of the research system by farmers and involved them in decision making and financing recognized that growth in funding would take place largely outside the public budget. New mechanisms like competitive funds at the national level are likely to become important ways of facilitating this new pluralism. The recent growth in the private sector in Latin America made this shift in structure and organization possible.

The three cases from sub-Saharan Africa illustrate different attempts to achieve a "fit" with their respective environments. Returning to our discussion of structure and organization from the introduction, we see that the countries have worked on the size and composition of the system (structure), the way tasks are allocated among actors (organization) and the mechanisms for making this work.

In Tanzania there were two issues: decentralization and devolution. The centralization of the system in the Department of Research and Training had been strongly supported by a key donor seeking rationalization of the institutes and a focal point for coordination of funding. However, administrative and program centralization in a large country with difficult communications proved not to be the best way to carry out research. As a result, the same key donor is promoting a decentralization of research to the zones following regional priority setting. The task is now to design the means for policy guidance at the central level while obtaining effective execution of programs at the zonal level. Accountability for funds remains ultimately with the DRT. Proposals to create an autonomous national institute, a national agricultural research council, and a national agricultural research fund are designed to facilitate program management and accountability at all levels. The devolution of responsibility for executing and financing of research to the private sector in selected commodities recognized the limitations of government finance. Moreover, the fact that government owned the research institutes was no guarantee of effective finance and operation.

The cases of Zimbabwe and South Africa illustrate adaptation of both structures and organization to changing political and financial environments. For these two national systems, this has mainly to do with reorienting the research effort towards a new clientele during a period of fiscal restraint. Both countries have historically had a strong research capacity, which, by original design, was focused on the technical needs of white commercial farmers. In recent years, the systems are being challenged to serve "emerging" farmers as well as address the needs of subsistence farmers in marginal areas. In many ways the task is to establish the policymaking apex which can determine the priority given to maintaining the productivity of the commercial sector, developing the potential of emerging farmers, and sustaining the welfare of people on land with low potential. Funding from local and central governments, private sector, and donors is linked to the choices those priority choices. The organization of research among the ADIs, ARC and other actors will follow.

In conclusion, the sustainability of a research system has much to do with the organizational "fit" of the system with its policy and economic environment. Structures may be designed to facilitate the mobilization of funding and to ensure that research is accountable to its financiers. Where funding is concentrated, the apex structures of a research system may also be concentrated and the mechanisms for financing research limited. Certain commodity research may exist in private or semipublic form outside the core of the public system where interested parties are organized or levies (and other forms of commodity taxes) are easy to extract. As the agricultural sector develops, the private sector may take over near-market R&D activities that were formerly in the public sector, and new mechanisms will emerge for giving clients a measure of control over the research agenda and financing of the services they require.

References

Agricultural Research Council, Republic of South Africa. 1995. Presentation at the Fifteenth SPAAR Plenary Session, March 20-22, 1995, Pretoria, South Africa.

Agricultural Research Council of Zimbabwe. 1995. The Crisis in the Department of Research and Specialist Services. Harare.

Byrnes, K. and S. Corning. 1993. Programming for Sustainability: Lessons Learned in Organizing and Financing Private Sector Agricultural Research in Latin America and the Caribbean. Washington, DC: USAID Bureau for Latin America and the Caribbean.

Chaparro, F. 1994. Nuevo Modelo Institucional Para la Investigación Agropecuario en Colombia: El Caso de CORPOICA. Ponencia presentada en la IX Conferencia Internacional de Arroz para la América Latina e Caribe. Marzo 21-25 de 1994. Goiania, Goiás, Brazil.

Churchman, C. W. 1979. *The Systems Approach.* New York: Dell.

Department of Research and Training (DRT) of the Tanzanian Ministry of Agriculture and Cooperatives, and ISNAR. 1997. Workshop on Policy and Financing of Agricultural Research in Tanzania: Follow-up Workshop to Develop an Action Plan, Dar-es-Salaam, January 8-9, 1997.

Echeverría, R. G., E. Trigo, and D. Byerlee. 1996. Institutional Change and Effective Financing of Agricultural Research in Latin America. Technical Paper No. 330. Washington, DC: World Bank.

Elliott, H. 1990. Applying ATMS Approaches in Widely Different Systems: Lessons from ISNAR's Experience. In *Methods for Diagnosing Research System Constraints and Assessing the Impact of Agricultural Research.* Vol. I. Ed. R. G. Echeverría. The Hague: ISNAR.

Harrison, D. 1996. The Role of the Private Sector in Agricultural Research in Tanzania: the Tea Industry. Paper presented at the Ministry of Agriculture, SACCAR, and ISNAR Workshop on Policy and Financing of Agricultural Research in Tanzania, *Proceedings of the Workshop on Policy and Financing of Agricultural Research in Tanzania*, Dar-es-Salaam, 2-3 September 1996. The Hague: ISNAR.

ISNAR. 1992. Service through Partnership: ISNAR's Strategy for the 1990s. The Hague: ISNAR.

ISNAR. 1995. Proceedings of the Roundtable on Research Policy and Financing in an Era of Adjustment. Workshop organized by SADC/SACCAR/ISNAR, Pretoria, Republic of South Africa, June 27, 1995. The Hague: ISNAR.

Kasaka, N. (Deputy Minister for Agriculture and Cooperatives, Tanzania). 1997. Quoted in *The Guardian*, Dar-es-Salaam, Tanzania, January 10, 1997.

Roseboom, J., P. G. Pardey, N. M. Beintema, and G. Mudimu. 1995. Statistical Brief on the National Agricultural Research System of Zimbabwe. Statistical Brief No. 20. The Hague: ISNAR.

Roseboom, J., P. G. Pardey, H. S. von Bach, and J. van Zyl. 1995. Statistical Brief on the National Agricultural Research System of South Africa. Statistical Brief No. 23. The Hague: ISNAR.

Sachdeva, P. S. 1990. A Framework for the Organization and Structure of NARS. In *Organization and Structure of National Agricultural Research Systems: Selected Papers from the 1989 International Agricultural Research Management Workshop.* The Hague: ISNAR.

Sarles, M. 1990. USAID's Experiment with the Private Sector in Agricultural Research in Latin America and the Caribbean. In *Methods for Diagnosing Research System Constraints and Assessing the Impact of Agricultural Research.* Vol. I. Ed. R. G. Echeverría. The Hague: ISNAR.

Shao, F. 1996a. Agricultural Research in Tanzania: Challenges, Constraints and Opportunities. Paper presented at the Ministry of Agriculture, SACCAR, and ISNAR Workshop on Policy and Financing of Agricultural Research in Tanzania, Dar-es-Salaam, 2-3 September 1996. The Hague: The Hague: ISNAR.

Shao, F. 1996b. Invited comments on The Perspective of the Tea Industry. Paper presented at the Ministry of Agriculture, SACCAR, and ISNAR Workshop on Policy and Financing of Agricultural Research in Tanzania, Dar-es-Salaam, 2-3 September 1996. The Hague: ISNAR.

Recommended Reading

Byrnes, K. 1992. A Cross-Cutting Analysis of Agricultural Research, Extension and Education in AID-assisted LAC countries. Washington, DC: LACTECH.

This two-volume report by the Agriculture and Rural Development Technical Services Project provides a wealth of data on the deterioration of technology generating and transfer capacity (TG&T) in Latin America and the Caribbean. It recommends a series of measures to facilitate the emergence of demand-driven (market-led) TG&T in the region's agricultural research, education, and extension systems.

Instituto Interamericano de Cooperación para la Agricultura. 1993. Fundaciones privadas de investigación y desarrollo agropecuario de América Latina y el Caribe: estrategia para acciones conjuntas/comp. Por Enrique Alarcón Millán. San José: IICA, Programa de Generación y Transferencia de Tecnolgía.

This volume contains papers from a workshop cosponsored by IICA and the Fundación de Desarrollo Agropecuario (FDA) of the Dominican Republic, and held May 5-7, May 1993. It includes papers on the role of the private sector and the experience of foundations in Latin America and the Caribbean.

Kaimowitz, D. (ed.). *Making the Link: Agricultural Research and Technology Transfer in Developing Countries.* Boulder, USA: Westview Press.

This volume contains seven conceptual papers commissioned as part of a multicountry study of research-technology transfer linkages. Particularly relevant are papers by Niels Roling, introducing a knowledge systems perspective, and by Roberto Martinez Nogueira on the effect of changes in State policy and organization on agricultural research and extension links in Latin America.

Kast, F. E. and J. E. Rosenzweig. 1985. *Organization and Management: A Systems and Contingency Approach.* New York: McGraw Hill.

This book presents a good review of systems and contingency approaches. The systems view of organizations and their management serves as a basic conceptual framework for understanding organizations of all types. The contingency view seeks to understand the interrelationships within and among subsystems, as well as between the organization and its environment, and to define patterns of relationships. Contingency views are ultimately directed towards suggesting organizational designs and managerial actions most appropriate for specific situations.

Special Program for African Agricultural Research (SPAAR), Multidonor Secretariat (MDS), European Centre for Development Policy Management (ECDPM), and United States Agency for International Development (USAID). Background Papers from the Sustainable Financing Workshop, September 12-15, 1995.

These background papers contain a concept note outlining the objectives and elements of an initiative to strengthen the financial basis of African institutions, as well as progress reports on a number of thematic and country diagnostic studies.

Part 2
Resource Mobilization and Accountability

Willem Janssen

Research managers increasingly recognize that public agricultural research systems can be made more healthy, more effective, and cheaper to run by being allowed to tap into different sources of funding. The public purse may remain the most important single source of money for quite some time, but the importance of other sources is on the rise. Resource mobilization strategies thus become a key element in the management of agricultural research. In the future, successful research organizations will be those that have diversified their funding sources, relying less on the central treasury.

Proactive resource mobilization strategies respond to a number of trends and factors:

- In many countries, the public sector is undergoing structural adjustment. Treasuries are under pressure to reduce public spending wherever they can. Independently of more theoretical arguments about the role of the public sector, they are seizing any opportunity they can to cut spending, and national agricultural research organizations are not exempt from these measures.
- Current opinion leans toward the idea that effective research is demand driven, even when the demand concerns long-term development. Supply-driven research, motivated from within the research system, is being edged out, then, by developmental research based on the expressed needs of farmers, ministries, development projects, regional authorities, and other groups.
- Research results have potentially very high value and it is the research manager's responsibility to see that this potential is realized. Research institutes therefore have to take responsibility for developing innovations to the point where they are appropriate for target users, as well as for initiating technology transfer. They may also have to protect their innovations from outside use by taking out patents, exercising plant breeders' rights, or securing some other form of protection.
- Results generated by national agricultural research are often true public goods—ones that benefit a large proportion of the population or advance basic scientific knowledge. However, other research results favor

narrower, more organized groups of people such as producers of export crops, often represented by farmers' associations. Economic theory suggests that the costs of research be charged to the farmers or their associations. Many research systems are now developing the means to start sharing costs with target producers.

- New demand for agricultural technology—for example, to meet environmental or agro-industrial needs—may come from government ministries such as industry or environment. This may happen even though funds for the required research are not included in the main budget allocation normally forthcoming from the treasury through the ministry of agriculture. Nevertheless, responding to such demand may help increase the funding base for public agricultural research.
- Part of the new demand comes from the private sector. Because public agricultural research organizations already have established capacity, they are often in a good position to respond to these needs. Being able to do so with full cost recovery (or more) can contribute to a more diversified and healthy funding position.
- Lump sum budget assignments are increasingly being replaced by project financing. In this situation, research organizations design projects in anticipation of, or in response to, the technology needs of public agencies and obtain funding from them. If the research organizations are able to identify the new demand correctly and develop adequate project-design skills, they can further diversify their funding sources even within the public sector. This reduces vulnerability to changes in the ministry of agriculture.
- Public-sector accountability standards are becoming more business oriented—that is, they are increasingly concerned with cost effectiveness, in addition to procedural correctness. The new principles of public-sector management are subjecting public agricultural research to intense scrutiny regarding effectiveness, efficiency, integrity, and transparency. A research institution's prospects for a prosperous future depend in part on how well these accountability requirements can be met.

In this part of the book we address issues surrounding improved resource mobilization and research accountability, which, in turn, are closely linked to enhanced relevancy of agricultural research. Improving the financial health of research institutions cannot be achieved in isolation from the actual research program.

The following six chapters are built on the premise that proper use of resources is no longer good enough—that it needs to be integrated with proactive strategies to acquire funds. The modus operandi of national research organizations would thus become more commercial, but within the limits of their assigned mandate and consistent with the pursuit of national development objectives.

The chapter by Janssen analyzes how both funding sources and modes are changing (e.g., from public-sector to private-sector sources, and from lump sum budget assignments to project funding). It reviews accountability requirements linked with these changes and reviews the feasibility of selected funding mechanisms. In their chapter, Baur and Mule suggest strategies to maintain public funding for research organizations, focusing on responsiveness, communication, accountability, and budget procedures. Fuchs-Carsch discusses, from a hands-on perspective, how research organizations in developing countries can pursue funding from external donors, and how they can manage donor interactions over time. Pray reviews experiences of research funding from the private sector and identifies conditions for success. Cohen, Crespi, and Dhar introduce the reader to the intricacies of intellectual property rights legislation and assess the implications for research organizations. In the last chapter, Eponou reviews the role of regional cooperation initiatives as a way to attract funds and enhance cost effectiveness.

Chapter 8
Alternative Funding Mechanisms: How Changes in the Public Sector Affect Agricultural Research

Willem Janssen

Introduction

Ideas about how the public sector should operate changed rapidly throughout the 1980s. While it is still recognized that public services must distribute benefits fairly, use resources carefully, and remain independent of partisan interests, other requirements are increasingly expected. The public sector must now also be cost effective, results oriented, client driven, and able to anticipate new trends (Osborne and Gaebler 1993).

At the same time, the mix of activities undertaken by public agencies has come under heavy scrutiny. Is there a real need for government involvement in certain activities, or can these be handled by the private sector? Many developing countries have had to provide strong, blunt answers to this question, often to the dissatisfaction of citizens, because of the need to trim back rapidly mounting government expenditures to a level supportable by government income (Tabor 1995).

Like other public-sector components, public agricultural research in developing countries has been feeling the pressure. Data for Africa, Latin America, and Asia, presented in other chapters, reveal the trend: agricultural research funding grew at a slower pace in the late 1980s and early 1990s than in the 15 previous years, or has even fallen (Pardey and Roseboom, chapter 15; Echeverría, Trigo, and Byerlee 1996; Pardey, Roseboom, and Fan, chapter 17). In many cases, operational budgets per scientist have shrunk and funding sources have changed. In Africa, donor funding appears to have grown in importance. In Latin America, private company contributions to the funding of national agricultural research institutes have increased. And, in China, self-generated income has become a more important source of research income.

Agricultural research systems thus have to respond to two interrelated developments. First, the changing perspective on the way governments should operate calls for increased accountability and is altering modes of funding. Second, the reduction of public research budgets, or slowdowns in their growth, implies the need for alternative strategies for mobilizing resources, i.e., exploring and developing new sources of funding. Links between the two trends are strong. The prospects for finding alternative sources of funding, including new government sources, depends strongly on being accountable for those funds (Taylor 1990). The issue is certainly not new (e.g., Trigo and Piñeiro 1982, Ruttan 1987, Sauer and Pray 1987); however, developments in research funding have recently become more dynamic.

The little evidence available on the subject suggests that the share of public funding in the total budget of national agricultural research systems (NARS) is falling, while the share from other sources is increasing (Figure 1, A). At the same time, more money is tied to specific projects, contracts, or conditions, which further reduces the resources that research institutions may allocate at their own discretion (Figure 1, B). In ensuring the financial base for their institutions, research managers thus need to react to changes in both the source and mode of funding. Many research institutes are quickly moving from the top left quadrant to the bottom right.

This chapter examines the arguments behind shifts in funding sources (arrow A in Figure 1) and funding modes (arrow B). It then explores how finding alternative funding sources depends on being accountable for these funds, and it identifies elements that contribute to improved accountability. Finally, the chapter reviews alternative funding mechanisms and examines how they may respond to calls for accountability and the need for improved funding. The evidence presented here draws heavily on earlier work by Echeverría, Trigo, and

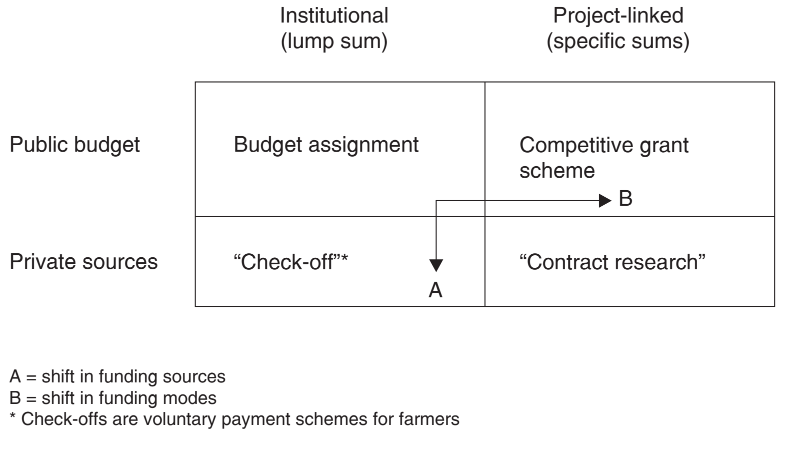


Figure 1. Funding trends in agricultural research during the late 1980s and early 1990s

Byerlee (1996). It is useful to read their chapter 16, (Part 4) of this book. In combination with the present chapter, it summarizes some of their earlier work.

The Shift from Public Funding to Private Funding

Agricultural research is often considered a public good. Because its benefits, in many instances, cannot be appropriated by the scientists (or institute) doing the work, there is little incentive for an individual to undertake research. Thus, if governments don't undertake agricultural research for some key areas of agricultural development, nobody will. There is also general agreement that research makes an important contribution to economic development. This is especially true in low-income countries, where agriculture is a major sector of the economy (Mellor and Johnston 1984).

For basic agricultural research, it is often unclear who the beneficiaries will be and, therefore, such research is a true public good. For applied and adaptive research, individual farmers can't be expected to take on the financing because the benefits to them wouldn't compensate for the costs. Most farmers would only be willing to finance research if all farmers shared the cost. And in such a situation, a mechanism for exacting payment would still be needed. Finding such a means may be feasible for export commodities, but perhaps more difficult for nontradables, especially when these are produced by resource-poor farmers. Also, when research makes products more widely available in the domestic market, prices may fall. The country's consumers would benefit from this, perhaps even more than farmers.

Agricultural research has traditionally been financed from the public budget mainly because farmers tend not to be organized and because the price impact of technological innovation tends to be society-wide. The national research system would receive a contribution from the government and allocate the money, based on available information, to various research options. Structural changes in the agricultural sector of many countries, combined with structural adjustment in the public sector, are now causing this reliance on the public sector as the main funding source to be challenged (e.g., Beynon 1995 and Hubbard 1995). Innovative research managers see this development as an opportunity rather than a threat and may try to increase their financial base by diversifying funding sources.

Structural change in the agricultural sector

Trade liberalization is a dominant trend of the 1990s. By the end of the decade, many countries will be cutting tariffs and lifting other protective measures. As a result, a given country's domestic prices will be shaped more by world market trends and less by domestic conditions, with the country becoming more of a price taker. Improved agricultural technology will then have less impact on consumer prices and more on producer incomes. In other words, the benefits of national research will accrue more to the producers, with society-wide effects being less strongly felt. As a result, agricultural research will be seen less and less as a predominantly public responsibility. The extent of these changes will vary from country to country, of course, and will be far more pronounced for tradables than for nontradables. But the overall effect will be to erode the rationale for public funding of agricultural research.

Other structural changes in agriculture include the growing number of producer organizations and the increasing integration of production in the agroindustrial sector through cooperatives, contracts, and other vertical marketing arrangements (Palma et al. 1995). Many producer organizations want a say in research; cooperatives or agro-industries, too, may express specific research demands. These groups may also collect funds for research—for example, by putting a levy on the produce they bring to market. Even where such organizations aren't yet able to mobilize resources to fund research, their perception of the constraints on agricultural production and their demand for better technologies are important inputs to the research agenda.

To sum up, the liberalization of international trade will reduce the society-wide price impact of domestic research-based technological innovation in agriculture. Coupled with the trend toward greater organization among farmers, this suggests that nonpublic sources will start playing a bigger role in defining and funding the agricultural research agenda.

Structural adjustment in the public sector

Government budgets have been severely curtailed in many countries. The distorting and sometimes devastating effects of continued public-sector deficits on national economic health, combined with limited capacity to collect taxes, have obliged many countries to slash public services. Agricultural research has not been spared this tough medicine and, in many cases, has had to hunt for nonpublic funds to survive.

Recent trends favoring public funding

There are also new trends that bolster the argument for public funding of research, though they aren't as strong as the economic and structural trends described above which favor a shift away from public support. One such new trend is the inclusion of natural resource management issues in the agricultural research agenda. For example, the cost to society of groundwater pollution due to excessive fertilizer use by farmers in the Netherlands is many times higher than the cost to the farmers. By making agricultural research respond mainly to its primary clients—farmers—important researchable problems may be neglected. Similar arguments can be made regarding the costs of erosion and of inefficient use of water. In some instances, then, demand from agricultural resource users may not fairly reflect the spectrum of important issues, and demand-oriented funding may bias research. Resolving these problems by bringing the different stakeholders of research together may be difficult. Farmers are often better organized and face more serious consequences as individuals than do nonfarmers. They can therefore be expected to take a stronger position at the bargaining table. Integrating public funding and decision making in a broad policy framework may lead to better allocation of resources for research.

Equity concerns also tend to favor public funding of research. Poor farmers have more difficulty mobilizing resources than large farmers and their voice can be easily drowned out in the symphony of demands. Arguments based on equity, however, have received attention for a long time, and it doesn't appear they are being assigned any more weight now than in the past.

The Shift from Lump Sum Mode to Project Funding

Cost effectiveness

In many countries, structural adjustment in the public sector has triggered not only funding cuts but also efforts to improve efficiency and accountability. The shift in funding modes now occurring in many countries is inspired by this desire to improve public agricultural research. As with other components of the public sector, the cost effectiveness of agricultural research systems is being questioned. Is research responding to the problems faced by agriculture and is it applying the most efficient tools to do so? Or is research concerned too much with the interests of researchers? If a research system is shielded from the outside world, it will sooner or later lose perspective on the practical problems it is intended to solve. The hypothesis is that, with a move from institutional to more competitive or project funding, the incentives for research to remain tuned in to the problems of the agricultural sector will be stronger, and research resources will therefore be used more effectively (Hess 1992).

Advantages and disadvantages of institutional funding and project funding

As early as 1980, institutional and project funding mechanisms had been analyzed by Bredahl, Bryant, and Ruttan. Just and Huffman (1992) analyzed in further detail how changes from institutional to project (grant) funding have affected the responsiveness of the US agricultural research system. Advantages and disadvantages of institutional and project funding mechanisms are presented in Table 1.

Advantages and disadvantages are often described in highly qualitative terms: creativity, continuity, demand responsiveness, and flexibility. But they are also presented in the hard numbers of direct cost effectiveness. For example, McKenney (1994) estimated that for forestry research institutions the average cost of obtaining a research dollar from a competitive grant fund was 22

Table 1. Advantages and Disadvantages of Institutional Versus Project Funding

	Institutional funding	**Project funding**
Advantages	– provides continuity to research projects – reduces transaction costs to the researcher – gives researcher more room for creativity – knowledge orientation	– increases the demand orientation of research and responsiveness to users – increases the chances of research efforts expanding in most relevant fields – provides room for specific clients to express their demand – output orientation
Disadvantages	– limited flexibility of research programs – accountability more limited – vision and strength of research manager defines relevancy of research – administrative overhead may grow unnoticed·	– rsearchers spend time chasing money, reducing efforts devoted to research – researchers may move into desk research, away from the field – short-term problems crowd out long-term problems – apparent disorganization of research institute – more tactics, less strategy

cents. These costs concern mainly the time needed by researchers to develop and submit competitive proposals. In addition, there were the costs of maintaining the public institutions that were managing the competitive grant schemes. If we add this cost to McKenney's estimate, it would be easy to imagine that the total cost of allocating resources amounted to 35 cents for every dollar spent on actual research.

When to expect a shift toward project funding

The move from institutional funding to some form of project funding is normally induced by the research financier rather than the research institute, which tends to lose some autonomy in the process. The change is often associated with the following developments:

- Confidence in decision making at a research institute declines. Some financiers then try to control resource use themselves rather than leaving this to research managers. They may also introduce competition for resources. This often points to a problem of governance. The institute's board may not command respect or may not be representative of the principal client groups. Senior research management may be seen as responding more to internal institutional pressures than to external demand.

- It may not be clear to outsiders what the impact of the research institute has been. Financiers may be worried that their funds will just add fat to the institute rather than produce good research.
- Financiers themselves come under increasing pressure of accountability. Although they may believe in the relevance of the research programs, the need to demonstrate concrete results may lead them to fund specific activities and to share explicitly in the credit for the outputs.

Project-by-project funding of research is probably more expensive than institutional funding. But, as argued by Becker (1982) and witnessed by all of us, there is no reason why the two funding modes can't operate side by side. The question is whether project funding allows research organizations to harness more resources. Where a government shifts from institutional to project-based funding, it is doubtful that resources actually increase. In the eyes of the financier, it is the enhanced responsiveness of the research system that justifies the shift. Where the shift to a project mode also enhances the institution's capacity to raise funds from other sources, there should be a positive effect on the overall funding base.

Alternative Mechanisms that Combine Changes in Funding Modes and Sources

In the preceding discussion, we broke down the shift in funding arrangements into two major elements: mode and source of funding. In practice, these tend to go hand in hand. It's difficult to imagine relying on a more diversified funding base without some kind of project funding arrangement being introduced. The following scenarios illustrate the interconnection between the two elements:

- The research institute's clientele is breaking into subgroups with different interests. The public nature of agricultural research is eroding and the subgroups try to pursue their own interests by direct rather than indirect funding. The more farmers contribute, the larger the share of short-term research projects may become (Gelb and Kislev 1982). This situation may well arise in the many countries where free trade regimes are being implemented. For farmer groups strong and organized enough to collect their own research contributions, such a development may be beneficial. Nevertheless, in cases where farmer groups are not sufficiently organized to fund research or simply do not have the necessary resources, care should be taken to ensure their research demands are addressed. This is especially important in the case of staple foods that play a key role in the agricultural economy.
- The demand is shifting from basic research to applied research such that problems, potential solutions, and possible beneficiaries can be clearly identified. In many developing countries, this situation may already exist for crop research. Major progress has been made in identifying genetic

sources of improvement (relatively basic research), and the agricultural sector's expectation is that this knowledge can now be used to overcome concrete constraints. The willingness to fund further basic research may be defined by the extent to which earlier results have been applied and adapted. For the applied research, willingness to fund will increasingly originate with the prime beneficiaries (often farmers). Public funding may exist for basic research, along with private funding for applied research, by means of a project mode.

Various alternative methods have been tried out by agricultural research systems to improve their funding situation. These include cost recovery, patenting, and selling agricultural produce. Certain authors suggest that such methods may not in fact greatly increase the research budget; rather, their main impact comes from sending a signal to the stakeholders of research that the system is responsive to their expressed needs (Alston and Pardey 1996). The accountability effect, with *indirect* consequences for funding, is thus greater than the direct effect on resource availability.

Alternative Funding Mechanisms: Success through Accountability

Nontraditional funding mechanisms, such as competitive project grants, cost recovery, patenting, and selling produce, may provide additional resources to the organization. But they require well-developed accountability procedures within the system if they are to be credible and acceptable to the main source of funding, often the treasury, and to new funding sources.

The main requirement for success with alternative funding schemes is a good accounting system. This provides appropriate reports to the treasury and to new financiers, showing how funds have actually been spent so that financial backers can evaluate their investments.

A second requirement is having the agreement of the treasury and the ministry of agriculture, as the primary sponsors of research, on the development of these alternative funding sources. It should be clear to all parties how the extra funds will affect the government budget. Research managers often feel that money acquired from alternative sources is legitimately theirs, while the treasury may want to incorporate it into the government budget. If the treasury isn't convinced the additional resources are being spent on the right things, it may reduce its own contribution disproportionately to those extra funds. Even if it believes the funds are being used wisely, it may consider the external resources a substitute for its own contribution, allowing it to finance some other urgent item on the public agenda.

A third requirement is that projects funded from alternative sources not end up being a drain on traditional resources. Especially in systems heavily dependent on institutional funds, small amounts of project-specific money may lead to major research efforts, which could divert money from other research.

In many cost-recovery or commercial-production schemes, earnings don't cover the institution's costs. Thus, a government subsidy is needed.

A fourth requirement for success is respect for institutional priorities. While an inflow of project money from alternative sources may enhance research on priority activities, there is also a risk of research projects being developed for the sake of a donor. Such undertakings may bear little or no relation to the research institute's mission. Another danger, in the case of cost recovery or commercial production by a research station, is that research may end up taking a back seat to fund-raising.

Finally, the research system needs to develop clear policies and procedures for managing project or donor funds and cost-recovery schemes. If cost recovery is applied in one instance but not in another similar one, the institution loses financial control. Three major issues arise in formulating internal policies:

- What exactly is the cost-recovery principle the institution wishes to apply? The scheme may apply to the operational costs of research, personnel costs, capital costs (e.g., of land and buildings), management costs of the project, management costs of the program in which the project is hosted, or the cost of overall institute management. In theory, as many categories as possible should be included in project costing; in practice, it's often impossible to charge more than operational costs, personnel costs, and a "fictitious" overhead rate.
- What is the internal path to be followed if researchers want to apply for special-project funding or set up a cost-recovery scheme? Such requests are normally assembled and coordinated at a central point in the organization and then subjected to an internal screening process.
- Is the internal capacity to manage project funds sufficient? Public-sector institutions often lack strong financial management expertise because they have long relied on the treasury or the ministry.

Review of Selected Alternative Funding Mechanisms

In recent years, many alternative funding mechanisms have been tried. Indeed, new ideas continue to germinate and be tested. Matching grants, competitive grants, levies, check-offs, endowment funds, donor funding, sales of services and consultancies, contracts, patents, and renting of land or research facilities have all been used as ways to improve the financial position and accountability of agricultural research. There are also cases where the private sector has funded public research (ISNAR 1995). Often several alternative funding mechanisms are combined, e.g., endowment fund and a competitive grant scheme, or a levy system and matching grants. In the rest of this chapter, rather than attempt to review all the options, we look at key approaches in light of several criteria that influence their feasibility and usefulness.

Criteria for reviewing funding mechanisms

As noted earlier, alternative funding mechanisms aim to increase resources, improve the quality and relevance of research, and enhance accountability. Assessment criteria should, of course, reflect these objectives. In addition, there are a few practical issues to consider, having to do with the ease and cost of operating these mechanisms and their expected performance over the long term. The following set of criteria thus seems appropriate for the assessment:

- **Additionality.** By how much will the new funding mechanism boost the research budget? Additionality means opening up *new* funding sources. A new source shouldn't drive out or otherwise alienate an old one. Neither should it be a simple repackaging of an old funding source.
- **Accountability.** To what extent will the funding mechanism improve the organization's goal orientation, the quality of its research, and its cost effectiveness? If such improvements occur, and if accountability to the existing primary funding source (often the treasury) is therefore enhanced, funding may increase or at least be put on a more secure footing. Accountability may thus have a long-term "additionality" effect.
- **Administrative cost.** Will the funding mechanism require extra resources to operate? For example, will special units within the NARS or special positions in research institutes be required? To be effective, such units or individuals, assuming they are required, may have to put a lot of effort into communication, information dissemination, and the development of linkages with new stakeholders. The decision to pursue an alternative funding scheme will be strongly influenced by the expected yield gain, i.e., the ratio of the projected additional income to the cost of collecting it.
- **Flexibility of research.** Will the alternative funding mechanism increase the institute's options for responding to stated needs beyond what traditional treasury-based funding may allow? For example, will it permit the institute to quickly shift research priorities to respond to an acute problem requiring short-term research? Will it allow the institute to pursue long-term research plans which, without alternative funding, might be on shaky ground? The flexibility criterion is closely linked with accountability in the sense of making research more responsive to expressed needs.
- **Sustainability.** Can the funding mechanism be maintained over the long run? In times of financial pressure, the tendency may be to make up funding shortfalls by whatever means are at hand. However, if research systems come to rely on unsustainable funding mechanisms, they are simply postponing a more drastic decline in funding not too far down the road.
- **Acceptability.** Does the funding mechanism have the support, whether active or passive, of key players in the national context? Is there opposition to it? Before developing alternative funding mechanisms, it is im-

portant to know who might find it acceptable and who might not. This can help the research system anticipate aids and obstacles to implementation.

It is difficult to provide quantitative generic estimates for these criteria, in part because they are so context-specific. A certain solution may be effective in one country but not in its neighbor. The following assessments of four alternative funding mechanisms, according to the above criteria, should be read with care since they represent an individual perspective based on limited experience and knowledge.

Patenting, plant breeder rights, and donor funding have been treated in separate chapters (see also Knudson and Pray 1991) and contracting and sales of services have been treated in the chapter on private-sector funding. Here we examine four mechanisms: matching grants; competitive grant schemes; levies and check-offs; and endowments. For a summary assessment of these, see Table 2.

Matching grants

In a matching grant scheme, the contribution is tied to the level of funding obtained by the research institute from other sources such as producer associations. There is often a ceiling on the contribution to avoid overburdening the sponsor of the matching grant.

The World Bank has instituted such a mechanism for its contributions to the CGIAR. It will make 12 percent available on top of the funding obtained by the international centers from other sources. In the Netherlands, the government has used matching grants for a long time in its applied and adaptive research structure. Experimental farms can have the funding obtained from commodity boards doubled by the government (Roseboom and Rutten 1996). More recently, Australia has introduced a matching grant scheme (Alston and Pardey 1996). As described in Box 1, Uruguay has also adopted this approach.

As a way to shift the funding of certain types of research from the public to the private sector, matching grants are very useful. Of course, they are provided on the understanding that the benefits of research will accrue mainly to the producers who provide the counterpart funds. Such schemes provide a high premium to farmers for organizing themselves, and they may thus play a role in public policies aimed at strengthening the institutional backbone of the agricultural sector.

Matching grants are an excellent way for the treasury to begin opening up additional funding sources. By adjusting its share, the treasury can influence the behavior of potential outside contributors. If, for example, it is willing to triple the funds obtained elsewhere by research, the incentive for new investors will be very high. Where the matching grant is small, e.g., below 25 percent, potential investors may not be strongly influenced, but the incentive for the research system to find additional money will remain high.

Through a matching grant scheme, the government loses some control over the spending of research resources, since allocation is determined by the

Box 1. Uruguay's Matching Grant Scheme

The national agricultural research institute in Uruguay underwent a major restructuring in 1990. This was based on increasing farmers' contribution to the newly created autonomous body.

Farmers pay a levy of 0.4 percent of the value of output at the first point of sale, which is earmarked for INIA. Under the law that established INIA, these funds are then matched by the government. All funds are administered by INIA, which is now a private, not-for-profit organization governed by a board consisting of two farmers appointed by producer organizations and two representatives appointed by the government. The board appoints INIA's national director and also guides the institute's overall priorities and strategies through weekly or bimonthly meetings.

Given these changes and its new autonomy, INIA is reducing the number of scientists while benefiting from a large budget increase. Scientists' salaries have been raised to competitive levels and operating budgets (as a proportion of the total budget) have likewise gone up. Ten percent of INIA's budget is allocated for the promotion of technology transfer and for funding research executed by the agricultural university and others.

Source: Echeverría, Trigo, and Byerlee 1996.

availability of other sources. From a national perspective, the accountability of a matching grant scheme may thus be questioned. The key to ensuring accountability is to identify those agricultural subsectors in which such a funding approach might work well. Normally these will be ones with well-organized producers to whom research will provide direct benefits. It may be that research on subsistence food production and on natural resource management cannot be financed successfully by matching grants. In this respect, the ideas of Von Oppen, Lamers, and Lichtblau (1996) regarding the initiation of a highly leveraged matching grant scheme for small farmers in some countries of West Africa can be called into question.

Matching grants generally do more to promote accountability than does institutional funding. The recipient research institute tends to be in closer contact with a paying client, and the willingness of the client to pay greatly depends on the relevance of the research.

Operating a matching grant scheme is relatively easy for its sponsor (e.g., the central treasury) since the grants are directly tied to evidence of other funding. For the recipient research institute, however, there are additional efforts and expenses involved in identifying the mandatory outside financiers (e.g., producer associations). Likewise, the new funding partners have to make the effort to set up internal mechanisms for deciding on the level of their contribution and on the research topics to which the funding should be directed. The sponsor of the matching grant scheme is therefore passing on part of the decision making to the new financier. If this helps focus research on the right topics, this transfer of responsibility is certainly warranted.

Extensive negotiations between the sponsor of a matching grant scheme and its partner financiers may be necessary. Additionally, the new partners may require a mechanism for raising funding themselves (e.g., a levy), in which case the overall cost of establishing the scheme increases dramatically.

Matching grant schemes force research institutes to respond to the research demands of their new financiers and to changes in that demand. Otherwise funding quickly dries up. The leverage effect of such schemes thus provides a strong incentive for research to be flexible.

Too much flexibility can, of course, threaten the continuity of the research program. One way to avoid this is to ensure that funding agreements and research plans run for several years. This requires tripartite negotiation and research planning involving the traditional financier, the new financier, and the research system.

Matching grant schemes are sustainable especially when there are clear ceilings imposed on funding. Nevertheless, there are risks. First, if no long-term agreements are in place on how funds are to be spent, opportunism by either the financier or the recipient research institute may lead to premature fatigue in their relations. Second, the funding base may develop in a way that is not in line with the orientation and policies of the traditional financier, who may then face difficulties in justifying the grants.

From the treasury's point of view, the initial appeal of a matching grant scheme is high, as it may lead to additional funding and possibly a reduced treasury contribution. Resistance may be expected, however, from research stakeholders unable to set up funding arrangements. A contentious issue that typically arises over the longer term is the size of the leverage factor, with the treasury hoping to reduce its share and other financiers wanting the treasury to contribute more. The debate reflects the difficulty in defining to what extent research is a public versus private good. The implicit recognition of the mixed public and private nature of agricultural research is a major strength of this kind of funding arrangement.

Competitive grants

In competitive grant schemes, institutions are invited to prepare research proposals according to predefined rules. The best proposals are then selected and funded. A small organization is normally responsible for managing the grant program and handles no more than two or three rounds of project applications per year. For each round, a budget ceiling is established. In large competitive grant schemes, priority fields of attention may be defined to guide the preparation of research proposals.

An essential trait of this funding mechanism is that it creates competition between possible suppliers of research services. This is most easily done in large countries with well-developed research systems.

Many countries manage a competitive grant scheme. In Colombia, this funding mechanism was an important element in the reorganization of agricultural research in the 1990s (CORPOICA 1995). Germany has a competitive grant scheme to manage collaborative research between German universities and the CGIAR system, and the European Union's scheme funds collaborative research across Europe. The National Science Foundation in the USA also runs a large competitive grant system. Box 2 gives two examples from Chile where the mechanism has been in use since 1981.

Box 2. Competitive Grant Funds in Chile

Fund for the Promotion of Scientific and Technological Development (FONDEF)

Created in 1991, FONDEF aims to link research conducted at the universities and other research institutions to the technological needs of production sectors. It is administered by CONICYT, the National Council for Scientific and Technological Research, and operates through a $70 million loan from the Inter-American Development Bank (IDB).

FONDEF periodically invites qualified institutions to submit project proposals in one or more of six priority areas such as fisheries and agriculture. The winners are selected in open competition. The fund can finance specific R&D projects or the development of technological infrastructure and services.

To date, there have been calls for projects with a total value of $61 million and funds have been allocated to 99 projects. Of these, 30 were in agriculture and forestry, for a total of $26 million, or 43 percent of total allocations. On average, FONDEF financed 46 percent of the cost of the projects, with the remainder provided by private firms and implementing institutions, including universities and the Instituto Nacional de Investigación Agropecuaria (INIA).

Initial evaluations indicate that the fund has had an important impact by attracting private resources to R&D. Also, since a significant proportion of the funds has been used to finance research infrastructure in participating research institutions, the impact of the fund is expected to extend beyond the currently approved projects. (Source: Echeverría, Trigo, and Byerlee 1996).

FIA, an agricultural research fund

FIA is a public fund created in 1981 by the Ministry of Agriculture to promote innovative agricultural research. It is governed by a council of independent researchers chaired by the Minister of Agriculture, and although public funds are its main source of resources, it also seeks private participation in research financing.

The funds are allocated competitively and are open to researchers of all public and private institutions. There is a two-phase call for projects. In the first phase, project "profiles" are requested. From these, ideas are selected for the second phase of the call, whereby proposals for implementation are solicited in an open competition.

Since its inception, FIA has disbursed almost $10 million to about 70 projects. Half the projects were implemented by universities, and the rest by INIA and other research institutions. Some private counterpart funding has been provided as well.

FIA is an active and transparent instrument promoting innovative thinking among researchers and research institutions. However, the two-phase call for projects has discouraged some research groups from presenting proposals because they fear their ideas may be "stolen" or allocated to another group during the second phase.

Source: Echeverría, Trigo and Byerlee 1996.

Strictly speaking, competitive grant schemes do not make more resources available. Rather, they affect the way resources are allocated. However, since financiers may feel more comfortable with competitive funding than institutional funding, overall resources for research may still increase.

Competitive grant schemes are an important tool for controlling the quality of research. Competing institutions must submit high-quality ideas to gain access to the funds. Over the years, such schemes may have allowed cutting-edge institutes to obtain more funding and grow, while marginalizing mediocre institutes. They function best where the key criterion for funding is scientific excellence, such as in basic and strategic research. For applied and adaptive research requiring close interaction with users, potential investors such as producer organizations may prefer to finance projects directly rather than going through a competitive mechanism.

By defining research priorities and the budgets for specific areas of attention, the body that runs the competitive grant scheme can pursue its policies and remain accountable to the treasury for its spending. A potential risk, especially in smaller research systems, is the emergence of a network of old friends and colleagues who indulge in informal decision making and favoritism. When a supposedly "competitive" grant scheme loses its objectivity and neutrality, it also loses its credibility.

These schemes are not cheap to run. They require the establishment of an organization with considerable scientific and financial skills—one that can screen and select projects and manage the grants. Under a competitive grant scheme, researchers also have to spend considerable time preparing project proposals that may never be funded. The assumption is that these costs are ultimately justified by the high quality of the resulting research and by the improved targeting of research on new problems.

Competitive grant schemes require researchers to tune in to the priorities of the funding institute. Flexibility at the research level is thus reasonably guaranteed. The question is whether the funding organization itself remains sufficiently flexible and open to new ideas. The choice of priority areas and selection criteria may lag behind scientific developments considerably. A peer review procedure for each scientific domain can help ensure the funding program remains flexible, provided of course that the pool of project reviewers is large and varied in its domains of expertise.

The biggest threat to the sustainability of competitive grant schemes is interference by research stakeholders intent on circumventing principles of objectivity and neutrality. As funds begin to be allocated outside the established process, the scheme may become marginalized. A second threat is easy access to other funding sources. This may diminish research institutes' need to compete and, as a result, quality standards for research become unenforceable.

For research institutes that previously received direct funding, a competitive grant scheme complicates access to resources. Thus, there may be some resistance to the scheme. For institutes that consider themselves superior in research, there may be substantial support for the funding mechanism. On balance, the treasury may be expected to support competitive grant schemes since they improve research quality and control over research spending. Producer organizations may not be in favor because their interest in the immediate relevance and applicability of research may be at odds with the funding scheme's interest in quality, which may imply scientific effort over a longer period.

Levies and check-offs

Levies and check-offs have more to do with generating resources than allocating them.

Levies are charges on agricultural production imposed by a government ministry or other legal authority—for example, a special department of the ministry of agriculture or finance, or a marketing board with exclusive buying and trading rights. Typically, levies are charged per ton of produce and collected at a central point such as a wholesale market in the case of domestically marketed production or a port in the case of exports. The key consideration in the use of levies is the feasibility of collecting the money.

Check-offs (Gilles and Albee 1995) are voluntary payments to research. A producer association, representing cotton growers for example, may decide that all members will pay a certain amount per ton of harvest. Here the voluntary aspect of the check-off is collective in nature. In the USA, check-offs have sometimes been applied with the stipulation that a farmer who does not agree with how the funds are spent can recover his or her contribution. In this instance, the voluntary aspect is individual in nature.

Levies for research are often combined with others in support of extension, stabilization funds, and marketing board operations. They are particularly popular in the cash crop sector. For example, they support coffee research in Colombia (Falconi 1993) and both tea and coffee research in Kenya (Beynon and Mbogoh 1996). This type of financing is expected to increase in the future. For countries where it is difficult to raise income taxes, trade charges through levies are easier to collect.

Levies have the advantage of allowing research on certain commodities to be funded directly by producers. In the case of export commodities, levy collection is a rather elegant way to adhere to the principle that, where possible, research should be financed by its main beneficiaries. An example of levy financing in Mexico is given in Box 3. Another example, from Colombia, can be found in chapter 16, by Echeverría, Trigo and Byerlee.

Where levies are being collected by the government (e.g., the customs office), they are often channeled to the research institute through the treasury. In this case, the levies will not likely boost overall funding; rather, they will increase the funding of research on the levied commodities. Where levies are collected by marketing boards and directly channeled to the research system, there might be an additionality effect. In most cases, the benefits will be enjoyed by export commodity research programs. Levies may thus be an important way to safeguard research resources for important cash crops.

Because they are voluntary, check-offs may have more impact on the availability of financial resources, especially in the short run. In the long run, one

Box 3. The Use of Levies in Mexico

Farmers in the irrigated northwest states of Mexico have a long tradition of providing financial support to local research stations. In the State of Sinaloa, research has been supported from sales of certified seed and by levies on outputs and inputs. However, beginning in 1985, a change in the cropping pattern led to a sharp drop in funding. Also, farmers of the region felt that, despite having paid part of the research budget, they had little influence on research priorities.

In 1994, the system of research funding was revamped to increase contributions from farmers but also to give them more influence over research priority setting and execution. Farmers now pay a levy of 0.16 percent of the value of production in irrigated areas, or about half of the total budget of the research stations in the state. In return, organizational structures were put in place to enable farmers to express priorities for research at the local level. In addition, a board of producers was established for each research station to help translate priorities into research projects and ensure that the projects are implemented.

Source: Echeverría, Trigo, and Byerlee 1996.

might expect the treasury to regard the sustained willingness of farmer groups to collect research funds as a sign that there is no longer a major need for public funding; thus, the treasury may try to withdraw. The issue then becomes whether the amount raised from check-offs is higher than that raised from taxpayers.

In principle, the way financial resources are collected shouldn't strongly influence the level of accountability for spending. Levies and check-offs, however, have two positive accountability effects. First, the resources obtained in this manner are earmarked, and the producers will carefully monitor how they are being used. They may even demand a significant say in how the money is spent and threaten to withdraw support if they are not involved. Second, levies and especially check-offs allow individuals to pass judgment, implicitly or explicitly, on the relevance of research. If researchers are working on irrelevant problems, farmers may start to emit strong signals by recovering their check-offs or pleading for reductions in the levy.

Levies and check-offs imply specific collection mechanisms which, of course, have costs. Their susceptibility to evasion also results in enforcement costs which can be considerable. For check-offs that permit individuals to be reimbursed if they so choose, there is also the cost of the repayment scheme. In developing countries, levies are economically feasible only for those products that pass through the formal marketing channel. Since check-offs depend on the presence of strong producer associations, they are probably feasible only for cash crops produced on a significant scale.

The fact that levies and check-offs generate earmarked funds almost guarantees that allocations to research will be carefully scrutinized by contributors. This very likely contributes to a research system which is responsive to changing demands.

The sustainability of levies and check-offs hinges largely on the strength of the agricultural production they support. If a country's position in the export market begins to erode, the earnings from an export levy will fall. For commodities with a sizable level of production, there is no problem in having funding linked to performance. But for products with growth potential and high demand for research, levies may not be able to generate sufficient resources and the levy mechanism may not be sustainable. Levies and check-offs may also become unsustainable if collection costs rise too high. Again, for products that are losing out in the market, this can easily happen. Levies and check-offs may also lose their appeal if they are not applied across the board in a credible manner.

In many countries, the treasury may be amenable to the use of an export levy, but it may not be willing to earmark the funds for research on a specific subject, as was the case in Argentina until the early 1990s. From a public finance point of view, non-earmarked funds, i.e., contributions to the overall pool of public resources, are preferable. Since check-offs are voluntary, in principle the treasury has no direct say here. Producer organizations and researchers working on "levy crops" normally favor levies and check-offs because funding directed to their research interests increases. For other producers and researchers, the question is whether the levies and check-offs can provide the research system with an added measure of budgetary flexibility to cover research not directly supported by these funding mechanisms. In the short run, levies and check-offs will most certainly do this; but in the long run, they may lead to further privatization whereby research not funded by its direct beneficiaries begins to disappear.

Endowments

Endowments are another way to fund agricultural research (Weatherly 1995). A sizable sum of money is set aside as a financial investment and research expenses are paid with the net returns (i.e., after taking into account inflation and fund management costs). The required size of the endowment depends on the return to capital and the value of research expenses to be covered. As a rule of thumb, the endowment's value should be 20 times greater than annual research expenses.

An endowment requires the establishment of a body to manage the fund. This is often a foundation and it has two main tasks: to ensure funds are wisely invested, with the right combination of projected returns and risk; and to define and implement a policy for spending the net returns.

Endowments have been established for funding of environmental activities in the Philippines and Madagascar and for orphan care in Tanzania (Weatherly 1995). INIAP-Ecuador is receiving part of its funding through an endowment fund in local currency (Tola, pers. comm.). As described in Box 4, IDB is considering an endowment fund to finance regional agricultural research for Latin America and the Caribbean (Piñeiro and Trigo 1996).

Box 4. Regional Fund for Agricultural Technology in Latin America and the Caribbean

Several countries in Latin America and the Caribbean (LAC) region are establishing an endowment fund to finance agricultural research of regional or subregional relevance. International organizations and non-LAC countries can also pledge money to the fund. The goal is to establish an endowment of $200 million during the period 1997-99. When consolidated, the fund is expected to have an annual budget of roughly $10 million and to maintain the inflation-corrected value of the endowment.

The fund is governed by a board consisting of representatives of the participating countries and institutions. Voting rights on the board are a combination of basic votes for each contributing LAC country and proportional votes based on the size of the contribution. The fund is managed by a Technical-Administrative Secretariat, which manages the screening of the project proposals submitted to the fund and the disbursement of funds. By the end of 1997, total pledges to the fund had reached about $100 million. The fund will begin to operate in 1998.

Source: Regional Fund for Agricultural Technology 1996. Operations Manual.

Since endowments provide an annual return independent of public budgets and spending policy, they are often considered a more stable source of revenue. This can be a big advantage for agricultural research which often requires long-term funding commitments not easily guaranteed in the public sector.

An endowment, then, is more often set up to ensure stable future funding than to increase the overall level of funding. Where it is created with nongovernmental monies, e.g., donations from individuals or donor agency contributions, it may have an additionality effect. The World Conservation Union, for example, is trying to establish endowments based on donations (Weatherly 1995). The question is whether agricultural research would have a similar appeal to potential donors.

Once established, an endowment may add funds, but the efforts needed to collect the initial capital are often enormous. In fact, coming up with the necessary capital is the key issue surrounding the feasibility of endowments.

By its very nature, an endowment foundation has a strong measure of autonomy, especially financial. This can result in research being pushed in a direction incompatible or not fully in line with national objectives for agricultural development. It's easy to imagine a situation where the governing body of an endowment acts based on its strong and perhaps controversial views about what farmers require from agricultural research. It is equally easy to imagine well-placed critics accusing the fund of not being publicly accountable. Combining financial independence with a sensible level of accountability is a major challenge for endowment funds. The key lies in their system of governance, particularly in having the right mix of people on the board that sets policy and formulates strategy.

As with any investment fund, the cost of administering an endowment, as a share of gross returns, falls with increasing fund size. Proper management of the investments depends heavily on having a high-quality, and therefore costly, financial team at the helm. The costs of disbursing funds to research, which may be similar to those incurred under a competitive grant scheme, must also be factored in. Finally, there are considerable costs associated with establishing the endowment. Funds have to be collected, normally by creaming off recurrent budgets; legal hurdles have to be removed; and a foundation may need to be set up. Nevertheless, where the opportunity to establish an endowment in a reasonable time frame presents itself, it should be pursued.

Endowment funds are often seen as a way to protect research from rapid changes in the environment, thereby allowing it the flexibility to pursue long-term objectives. The other side of the coin is that, by providing this protection, endowments may end up confirming research that is no longer relevant. Again, it is the governance of the endowment that determines flexibility and responsiveness.

Since endowments operate on the returns to financial investments, they are often considered highly sustainable. With good financial management, this should indeed be the case. Three factors may, however, undermine the sustainability of research funded through an endowment. First, the returns to investment may not be as stable as the fund's architects may have originally wished. This problem can of course be partially avoided—for example, by investing in bonds rather than stock market shares—but then the long-term return of the endowment may be seriously affected. Second, in developing countries there isn't always a sufficiently developed and stable capital market to operate an endowment fund. Here again, it will be difficult to obtain a stable return. Third, there may be pressure on the endowment fund to use part of its capital for operational spending, in which case the future base for operations would obviously be threatened.

The research system itself will favor the establishment of an endowment because it gives scientists the security and independence they need to do high-quality research. Ministries of finance and agriculture may oppose such a move because it would reduce their control over research spending and therefore the ease with which research can be used as a policy instrument. The level of acceptability, then, is defined by the potential gain or loss of control over research spending. When an endowment fund is planned as a means of evading public accountability, resistance may be so intense that the project never even sees the light of day.

Table 2. Characteristics of Four Alternative Funding Mechanisms

	Funding mechanism			
Criterion	**Matching grants scheme**	**Competitive grant scheme**	**Levies and check-offs**	**Endowment fund**
Additionality	Good way to start pulling in new resources	Possibility of an indirect positive effect on funding	Good way to obtain additional resources, if not compensated by treasury	Focus is not on additional resources but on stability
Accountability	Improves through rapport with new financiers	Good if grant scheme is fairly operated	Good because of more direct links with users	Depends on quality of governance
Administrative cost	Depends on having a feasible collection point for new resources	Substantial, both for financier and research body	Depends on having a feasible collection point	Substantial
Flexibility / responsiveness of research	Research becomes more demand driven and often more applied	Improved response to quality requirements	Research becomes more demand driven	Research can pursue long-term plans
Sustainability	Depends on willingness of new financiers to contribute	Adequate as long as scheme is fairly operated	Depends on industry size	Depends on earning even returns
Acceptability	Good with producers, good with treasury	Good with treasury, mixed with producer organizations and research institutes	Mixed with treasury, good with producer organizations	Poor with treasury, good with research community

Concluding Remarks

Alternative funding mechanisms for agricultural research have been in the spotlight in recent years. Research managers are interested because they see potential for increasing resources for their work, thereby allowing their institutions to grow, or at least to maintain stable budgets. Policy makers are also interested. First, they see alternative mechanisms as a way to promote higher-quality science that is also more relevant to their concerns. Second, they see the potential for research organizations to become more accountable for their spending and more flexible in their work. One conclusion is that alternative funding mechanisms will be viable in the long run only if they satisfy, at least partially, the concerns of both groups. In particular, they will be able to enhance research resources over the long term only if they also improve accountability.

For two of the four alternative funding schemes (matching grants and levies/check-offs), the accountability of research is enhanced through greater involvement of research clients in funding. These schemes are thus also particularly well suited to addressing flexibility and relevancy concerns. For competitive grants, increased accountability comes mainly from predefining criteria for research and by choosing those projects that best address those criteria. At the same time, competition among researchers helps to ensure the scientific quality of research. In the case of endowment funds, which aim to secure a stable flow of funds over the long term, accountability needs to be guaranteed by means of strong governance.

The potential improvement in the research system's accountability to various stakeholders varies between funding mechanisms. Matching grants and levies respond mainly to producer concerns, but may not lead research to pay greater attention to environmental or consumer issues. Competitive grants raise research's accountability to the scientific community, but not necessarily to producers. Decisions on which funding mechanisms to adopt thus need to be preceded by an assessment of where accountability should be improved. Of course, alternative mechanisms can also be combined to improve the responsiveness of research.

Compared with more traditional institutional funding, alternative mechanisms are often thought to have higher initial costs for fund-raising. Yet, some management tasks, which in the case of institutional funding have to be undertaken in addition to the transfer of funds, are built right into the alternative funding mechanism. For example, in competitive grant schemes, resource allocation is implicitly decided. In matching grant schemes and levies, decisions on budget size are based less on deliberations within the treasury or ministry of agriculture than on client assessments of the research program. Nevertheless, alternative funding mechanisms should not be adopted with the aim of reducing the administrative costs of financing research.

Since alternative funding mechanisms will often be initiated at the iniative of the traditional public funding agencies, a prime condition is to have an accounting system that can handle the different funding modes. In addition, researchers will need to spend more time justifying their projects and programs, and research leaders will have to put more effort into maintaining contacts with clients. Where alternative funding mechanisms have been successfully applied, success came mainly from the increased responsiveness of research to public policy, sector developments, or producer concerns.

References

Alston, J. M. and P. G. Pardey. 1996. *Making Science Pay: The Economics of Agricultural R&D Policy.* Washington, DC: American Enterprise Institute Press.

Becker Jr., W. E. 1982. Behavior and Productivity Implications of Institutional and Project Funding of Research: Comment. *American Journal of Agricultural Economics* 64:595-598.

Beynon, J. 1995. The State's Role in Financing Agricultural Research. *Food Policy* 20:545-550.

Beynon, J. and S. Mbogoh. 1996. Financing of Agricultural Research and Extension for Smallholder Farmers in Sub-Saharan Africa: The Case of Agricultural Research in Kenya. Oxford, UK: Food Studies Group, Oxford University.

Bredahl, M. E., W. K. Bryant, and V. W. Ruttan. 1980. Behavior and Productivity Implications of Institutional and Project Funding of Research. *American Journal of Agricultural Economics* 62:371-383.

CORPOICA. 1995. La programación de 1996. Un paso firme hacia la consolidación institucional. Bogotá, Colombia: Corporación Colombiano de Investigación Agropecuaria.

Echeverría, R. G., E. J. Trigo, and D. Byerlee. 1996. Institutional Change and Effective Financing of Agricultural Research in Latin America. World Bank Technical Report No. 330. Washington, DC: Inter-American Development Bank and World Bank.

Falconi, C. 1993. Colombia: Relaciones entre los sectores público y privado en la investigación agrícola. Briefing Paper No. 1. The Hague: ISNAR.

Gelb, E. and Y. Kislev. 1982. Farmers' Financing and Agricultural Research in Israel. *Research Policy* 11:321-327. North Holland Publishing Company.

Gilles, J. L. and R. Albee. 1995. Check-offs. In: *Sustainable Financing Initiative for Africa.* Executive Summaries. University of Missouri, College of Agriculture, Food and Natural Resources, Social Science Unit, and USAID/AFR/ARTS/FARA.

Hess, C. E. 1992. Funding Strategies for Agricultural Research Challenges. *HortScience* 27:201-203.

Hubbard, M. 1995. The "New Public Management" and the Reform of Public Services to Agriculture in Adjusting Economies: the Role of Contracting. *Food Policy* 20:529-536.

Just, R. E. and W. E. Huffman. 1992. Economic Principles and Incentives: Structure, Management, and Funding of Agricultural Research in the United States. *American Journal of Agricultural Economics* 74:1101-1108.

McKenney, D. W. 1994. On the Cost of Chasing Research Dollars. *Canadian Journal of Agricultural Economics* 42:105-112.

Mellor, J. W. and B. F. Johnston. 1984. The World Food Equation: Interrelations among Development, Employment and Food Consumption. *Journal of Economic Literature* 22:531-574.

Oppen, M. von, J. P. A. Lamers, and M. Lichtblau. 1996. Research for Agricultural Development in West Africa: Efficiency Gains through a System of Actors Connected by Flows of Funds and Knowledge. Stuttgart, Germany: University of Hohenheim.

Osborne, D. and T. Gaebler. 1993. Reinventing Government: How the Entrepreneurial Spirit is Transforming the Public Sector. New York: Plume.

Palma, V., P. Serra, and C. Bay-Schmith. 1995. La Cadena Agroalimentaria: Nuevas Oportunidades y Desafíos para la Investigación. Paper presented to the Executive Committee of the Programa Cooperativo de Investigación Agropecuaria del Cono Sur (PROCISUR), July 1995.

Piñeiro, M. and E. Trigo. 1996. The Regional Fund for Agricultural Research: a Proposal to Consolidate the Regional System of Technology Innovation. Washington, DC: Inter-American Development Bank.

Regional Fund for Agricultural Technology. 1996. Operations Manual. Washington, DC: Inter-American Development Bank.

Roseboom, J. and H. Rutten. 1996. Financing Agricultural R&D in The Netherlands: The Changing Role of Government. In *Paying for Productivity: Financing Agricultural R&D in Rich Countries*. Eds. J. M. Alston, P. G. Pardey, M. Philips, and V. H. Smith (draft).

Ruttan, V. W. 1987. Agricultural Research Policy and Development. FAO Research and Technology Paper No. 2. Rome: Food and Agriculture Organization of the United Nations.

Sauer, R. J. and C. E. Pray. 1987. Mobilizing Support for Agricultural Research at the Minnesota Agricultural Experiment Station. In: *Policy for Agricultural Research.* Eds. V. W. Ruttan and C. E. Pray. Boulder, USA: Westview Press, Inc.

Tabor, S.R. (ed.). 1995. Agricultural Research in an Era of Adjustment: Policies, Institutions, and Progress. EDI Seminar Series. Washington, DC: The World Bank.

Taylor, T. Ajibola. 1990. Funding of Research in National Agricultural Research Systems (Issue 2). Paper presented at the International Agricultural Research Management Workshop: The Organization and Structure of National Agricultural Research Systems, November 5-9, 1990. The Hague: ISNAR.

Tola, J. 1997. Endowment fund for INIAP. Per. comm.

Trigo, E. and M. Piñeiro. 1982. El Financiamiento de la Investigación Agropecuaria. San José: Instituto Interamericano de Cooperación para la Agricultura (IICA).

Weatherly, P. 1995. Handbook on Endowments: Using Alternative Funding Mechanisms to Support Agricultural and Natural Resources Management Programs in Africa. Washington, DC: United States Agency for International Development.

Recommended Reading

Alston, J. M. and P. G. Pardey. 1996. *Making Science Pay: The Economics of Agricultural R&D Policy*. Washington, DC: American Enterprise Institute Press.

This provides a concise and comprehensive overview on past, present, and future benefits of agricultural research and of the rationale for public and private support for agricultural research, mainly for the USA.

Beynon, J. 1995. The State's Role in Financing Agricultural Research. *Food Policy* 20:545-550.

This article gives an up-to-date overview on the rationale for public investment in agricultural research. It also discusses how the rationale has been changing over the years and what the implications are for research funding.

Echeverría, R. G., E. J. Trigo, and D. Byerlee. 1996. Institutional Change and Effective Financing of Agricultural Research in Latin America. World Bank Technical Report No. 330. Washington, DC: Inter-American Development Bank and World Bank.

The publication takes the reader through a discussion of developments in agricultural research funding in Latin America in the late 1980s and early 1990s. It describes how public research systems in different countries reacted to financial stress, especially by experimenting with alternative funding mechanisms.

Gilles, J. L. and R. Albee. 1995. Check-offs. In: *Sustainable Financing Initiative for Africa*. Executive Summaries. University of Missouri, College of Agriculture, Food and Natural Resources, Social Science Unit, and USAID/AFR/ARTS/ FARA.

This volume provides further insights and ideas for the application of check-off schemes. It treats not only financial, but also organizational and legal aspects. It is very useful for institutions that want to start a check-off or levy system.

Piñeiro, M. and E. Trigo. 1996. The Regional Fund for Agricultural Research: a Proposal to Consolidate the Regional System of Technology Innovation. Washington, DC: Inter-American Development Bank.

This proposal concerns the development of a regional endowment fund for agricultural research in Latin America. The document is useful not only to readers wanting more information on endowments, but also to those interested in the disbursement of research funds through competitive grants.

Weatherly, P. 1995. Handbook on Endowments: Using Alternative Funding Mechanisms to Support Agricultural and Natural Resources Management Programs in Africa. Washington, DC: United States Agency for International Development.

Practical information on how to start up an endowment fund, overcome the major problems encountered, and establish an adequate legal basis are given in this handbook. A number of cases are discussed, including nonagricultural ones.

Chapter 9
Four Strategies for Protecting Public Research Funding

Henning M. Baur and Harry M. Mule

Introduction

The appropriation of public funds for agricultural research seems to get ever more difficult. Public expenditure is under pressure in many countries and there is concern over the performance of public agricultural research. Most public national agricultural research organizations (NAROs) need to adjust their missions and adapt their internal procedures if they are to remain well-funded at a time when society in general and agriculture in particular are rapidly changing.

Although maintaining high scientific standards and managing research efficiently are important, they are not enough. Most governments expect more of NAROs. Research managers need to make special efforts to maintain institutional credibility and to make the idea of public funding of agricultural research more appealing. Research results need to be disseminated and applied to ensure that the beneficiaries of research, policy makers, administrators, and budget officials are aware of their positive impact. Adequate support for research can only be obtained and sustained if these people see successful development and diffusion of technologies suited to farmer needs and consistent with overall agricultural policies and priorities.

Research leaders can follow two approaches to increase the appeal of agricultural research funding. First, they can adapt the organization to the policy environment by adjusting the research plan. Second, they can be more proactive by mustering as many allies as possible to lobby for sustained support. The question is not which approach to choose, but how best to combine them. The optimal blend will differ from country to country and organization to organization. For example, scrapping a research program is not an effective way to cut costs in an organization where salaries consume most of the available budget and cutting staff is not an option.

In daily practice there is a lot research leaders can do to maintain or increase public funding. Most of these activities will contribute to improvements in one of four areas:

- the organization's responsiveness;
- the organization's communication strategy;
- institutional accountability;
- management of the budgetary process.

Responsiveness

Contribute to the achievement of policy objectives

Agricultural research is not an end in itself. To maintain and foster public support, agricultural research must produce knowledge and technologies that respond to the policy objectives of the government. This can only happen if those objectives are clearly defined and publicized and if the research institute and individual scientists are willing and able to respond.

Neither policy makers nor research leaders should take these conditions for granted. Many countries don't have an explicit agricultural policy and many NAROs aren't fully plugged into policy formulation. It is the research leader's job to ensure scientists are aware of the government's economic policy and its implications for their work.

In many countries, new challenges like environmental protection and the assessment and adaptation of imported agricultural technologies have taken on new importance. These are opportunities for agricultural research and have considerable potential for attracting public funding. But many NAROs have been slow to capitalize on new trends. Either they don't have adequately trained staff available, or else the new demands are thought to be beyond the scope of the institute's traditional mission. It is important, nevertheless, for all NAROs to be able to anticipate new or future research needs.

NARO leaders need not wait for the government to communicate agricultural R&D objectives. They can take the initiative and develop a vision for their country's agriculture. The more a NARO succeeds in formulating appealing ideas for future agricultural production, the more it will be able to stabilize the need for agricultural research and present itself as the institution most apt to provide the required solutions.

In doing this, most NAROs will have to deal with their parent ministry. In most cases, this is the ministry of agriculture or rural development, or the ministry of science and technology. Whatever mission is set for the NARO, it must mesh with the policy of the parent ministry because the staff of this ministry will play a crucial role in defending the NARO budget at the political level.

Develop a research strategy

Successful anticipation of research demand and opportunities requires a long-term perspective. To develop this, strategic planning is particularly useful, especially where NAROs face new technological challenges, rapid changes in their macroeconomic environment, or policy shifts. Analysis of stakeholders' expectations, part of strategic planning, is an excellent starting point for intensifying the NARO's dialogue with policy makers. Also, the analysis of the NARO's external environment can help make researchers more client-oriented.

To formulate a strategy, the research organization must interpret stakeholder demand and define how it wants to respond to it. The strategy should be widely published both to demonstrate the organization's commitment and to allow all interested parties to see what the research organization is going to do to satisfy their expectations.

A long-term research strategy aimed at developing future institutional strengths does not substitute for operational research plans. Within the strategic fields chosen, such operational planning is needed to respond to short-term concerns. Focused research projects and programs are critical since they allow the ministry to see how the NARO is responding to policy directions.

Formulate convincing programs

Governments want agricultural research to contribute to national development and will provide financial support only if they believe in the quality and usefulness of the planned research. Convincing programs and projects depend on the use of relevant methods and criteria in the planning process and lead to socially desirable results (e.g., Collion and Kissi 1995, Janssen and Kissi 1997).

There are many different criteria for evaluating research programs. Smith (1994), for example, suggests that research administrators evaluate research proposals on administrative, utilitarian, and scientific criteria. First, from an administrative point of view, output-oriented research programs are essential because they can be precisely evaluated. Second, research programs must address problems whose solution is likely to result in applicable, useful technologies. Third, research programs must be based on valid and carefully articulated scientific methodologies.

As a minimum, research programs should

- address important problems or opportunities;
- specify outputs, as a function of the program objectives;
- target a defined group of users or beneficiaries;
- undergo peer review;
- contain a detailed budget;
- be available in the common style and format used by the parent ministry and the treasury.

Communication

Agricultural researchers feel comfortable talking about research methodology, agronomic problems, new varieties, and so on. That is their world. Research budgets, however, are quite a different matter. Getting them accepted by the ministry of finance brings research leaders into a different, sometimes frustrating world. Those seeking to increase or maintain the ministry's contribution to the research budget need to ensure, among other things, effective and mutually satisfactory communication between the research organization and the people and organizations in its environment.

It is useful to think of the NARO as part of a greater agricultural knowledge and information system (Röling 1990, 1992). Agricultural research contributes to knowledge and development processes in which many other actors such as farmers, extension services, technology users, policy makers, and administrators are engaged. Effective communication with these groups is essential for identifying threats and opportunities, for developing a well-justified research agenda, and for producing high-quality research services appreciated by the government and technology users.

Here we will focus on three ways a research leader can improve communication between the NARO and other actors in the knowledge system:

- by developing a communication strategy for the research institute;
- by maintaining (or improving) productive dialogue with policy makers;
- by forming coalitions of supporters.

Develop a communication strategy

As an organization becomes more professional and efficient, it tends to adopt more specialized terminology, norms, and operating procedures not easily understood by outsiders. This can make it more difficult to communicate and collaborate with other organizations. It is important, then, for any modern research institute to design and actively promote mechanisms for information exchange, learning, and mutual understanding. Formulating a strategy that gives clear focus to the institute's many communication activities is one way for the NARO to improve its dialogue with policy makers and other actors in the agricultural knowledge system.

To develop a communication strategy one must first know what needs to be communicated, to whom, and to what end? Which audiences are currently being reached? Which ones are being missed? What are the key institutional messages to be transmitted? What products and services are being produced? What feedback has been received from different audiences? What human and technical resources are now being devoted to communication? Once these questions have been answered, the attention may turn to the more technical concerns such as the choice of media. Most NAROs would likely need outside professional assistance in designing a communication strategy.

A communication strategy needs to be tailor-made for the organization. The single most important point to consider in its design is that effective communication, as a two-way interaction between consenting partners, causes people to change their thinking and actions. The research institute's communication with its outside environment is therefore not a question of outward information flow only. Researchers have to enter into an intimate dialogue with both technology users and policy makers to find out what their problems and aspirations really are, to understand how they think, and to design their public relations accordingly (see Box 1).

Box 1. Baseline Study of Public Relations in Uruguay

To find out how public relations works in a NARO, ISNAR conducted a study of the PR activities of the Instituto Nacional de Investigación Agropecuaria (INIA) in Montevideo, Uruguay. The study showed the breadth of INIA's work in this area and made recommendations on how it could improve its PR without incurring major expense.

The study found that the number of PR activities at the institute increased from 90 in 1991 to a peak of 416 in 1993. The figure for 1994 is slightly lower due to financial constraints. Most PR is conducted at the regional level by research stations. Regional advisory councils at each research station, known as the "lungs" of INIA, provide an important forum for a regular exchange of views between farmers and INIA staff. Researchers themselves produce most publicity materials. These are sometimes seen by farmers, policy makers, and other stakeholders as "too technical". For policy makers, personal contacts are seen as INIA's most important PR instrument. The institute also produces a wide range of information materials, including brochures, magazine and newspaper articles, and radio and television programs featuring its work.

Three of the main recommendations of the study were that INIA publicity materials should be used more to put research in the broader context of issues such as transportation, education, marketing, and the economy; that INIA should make its information less technical; and that INIA should draft a formal PR policy and strategy. The policy would identify target groups and objectives for each group, list activities and responsibilities, and provide for regular evaluation and a specific budget.

Source: ISNAR Newsletter, No. 30, April 1996.

Research leaders must develop organized communication activities, each tailored to a different need: scientific communication with peers, marketing of know-how and services, enhancing credibility with policy makers, building public awareness about farmers' needs. Each activity requires a degree of analysis and planning.

The marketing of research results is currently attracting the interest of many NAROs struggling with a changing environment and stagnating financial resources. Unfortunately, many researchers think marketing is only about selling, advertising, or public relations. They tend to ignore the fact that marketing also includes needs assessments, market research, product development, and so on. Kotler (1986) argues that "… the most important part of marketing is not selling… . Selling is only one of several marketing functions, and often not the most important one. If the marketer does a good job of identifying consumer needs, developing appropriate products, and pricing, distributing, and promoting them effectively, these goods will sell very easily." For example, it would be a mistake to start an image campaign without ensuring that the organization can live up to that image and provide services according to the expectations created.

Urban consumers, and the general public as a whole, are also an important audience for public agricultural research because they strongly, though indirectly, influence the allocation of the national budget in most countries. It is important for society to know what agricultural research is doing and how it operates. An example of a successful effort to strengthen public awareness is given in Box 2.

Box 2. Reaching the Brazilian Public

In 1984, the Brazilian research organization EMBRAPA launched a project to inform Brazilian society about its work. Since television was the predominant information medium, EMBRAPA approached a communication company to produce a series of short films about the organization. These were broadcast on the nation's main television channel during prime time, on the evening news. Almost 80 percent of the total public was reached.

The project goal was to reach urban consumers. The subjects on which the campaign was based were chosen to reach the heart of consumer feelings. For example, one film opened with a scene from the central marketplace of a typical Brazilian town at sunrise. The sound of a bell is heard and a cow enters the scene. More animals arrive and then a voice says: "If you ever wondered where your food comes from, ask EMBRAPA." In a survey after the broadcast, EMBRAPA was rated the second most important organization in Brazil, after the postal service.

The films were professionally produced and spectators affirm that they remembered these images many years later. EMBRAPA's success could not have been achieved just with technical skills and equipment. The essential ingredient was the vision of future agriculture that EMBRAPA developed, including research's pivotal role in solving problems.

EMBRAPA was also very active in communicating with top-level policy makers, both officials in the Ministries of Agriculture and Planning and members of the legislature. To this end, key individuals were invited to visit EMBRAPA's research stations. By convincing the President of the country, a sufficiently large number of members of the Congress, and the general public, the need for agricultural research was successfully conveyed in Brazil.

Sources: Alves 1987 and Helio Tollini, pers. comm.

A NARO that has instilled in its staff a strong outward-looking perspective will use any available communication medium to capture and disseminate information: printed materials, audiovisual media, budget hearings, planning workshops, seminars and conferences, field days, inauguration events, rapid appraisals, lobbying through distinguished opinion leaders and alumni, and so forth.

Maintain effective interaction with policy makers

Research leaders and policy makers have different messages for each other. The former need to communicate the potential output of the research system and the potential usefulness of research results. The latter need to convey to the research community what the needs of the government are and what outputs they expect from research. If this isn't done, research leaders should try to get the necessary information to give direction to their institution. In a nutshell, policy makers must set clear goals and send down indicative targets, while researchers must send up feasible programs and assessments of their impact on society.

Efficient communication with ministries of agriculture and finance requires research leaders to learn the language of policy makers and understand their concerns. In the case of finance ministries, the NARO may have to invest considerable time and effort. Moreover, every time a new policy maker takes office, the research leader must establish links with a person who may know little about agricultural research.

It is very useful to know something about policymaker's professional backgrounds and what motivates them. Many are economists, financial experts, lawyers, or administrators. They are more likely concerned with trade balances, economic growth, fiscal deficits, and return on investments than with crop varieties, vaccines, pest control, or soil quality. It is of paramount importance that research managers link their research programs and budget requests to these concerns.

A good way to improve the quality of communication is to create opportunities for people to get to know each other. Bringing together research institute staff and ministry officials for workshops and seminars, for example, is a good way to share information. It also enhances creativity in ways that more formal communication channels can not.

To sum up, only when NARO managers put themselves in the shoes of some of their most important clients—government ministries—can they acquire a realistic perspective on the research services their organizations are providing. As clients, ministries care little about "interesting" scientific problems; what they are on the lookout for is promising solutions, especially when the payoff can be made explicit in terms of money, people, or regions. NAROs shouldn't expect ministries to tailor their procedures to research. On the contrary, agricultural scientists have to adapt their services to the needs of their government and communicate accordingly.

Form coalitions of supporters

In seeking budgetary funding, agricultural research is just one among many claimants. All the spending agencies present their budget requests and argue that their programs are essential for the well-being of the country. To compete successfully with these claimants, the NARO should mobilize political support for its activities and budget. This means building broad-based coalitions within the principal ministries and client groups to support agricultural research. In this respect, the members of the research organization's governing board play a very important role in the political domain.

Broad support from the national scientific community is also important. Scientific peers and research administrators of other organizations need to be convinced of the quality of the NARO's work. In countries where agricultural producers or agro-industries are well organized and influential, these professional organizations can be powerful allies of research. Their support strongly improves the NARO's negotiating position when it submits its budget request.

Accountability

Public agricultural research institutes are accountable to at least three groups: the government, technology users, and the scientific community. Each group has different expectations, though these may overlap. The government will consider a NARO accountable if there is proof that programs have produced agreed-on outputs and that resources have been used efficiently and legitimately. For technology users, the emphasis will be on the relevance and applicability of research results, as well as the costs of new technologies. In the eyes of other scientists, accountability will lie mainly in the rigor of the research methodologies used by the NARO, the repeatability of documented experiments, and the contribution to new knowledge.

Accountability has both a political dimension and a managerial dimension. The former has to do with whether research is producing outputs that contribute to national development goals as defined by the government. The latter relates to whether tasks have been accomplished according to agreed criteria of performance. An essential obligation of research leaders is to provide information certifying the accountability of the NARO. Continuous and careful attention to this helps ensure sustained public funding.

There are basically two complementary tools available for the task: evaluation and auditing. Evaluation is of paramount importance for the NARO. It shows whether agricultural research is producing benefits for society that would not have been achieved without research. Auditing establishes whether the NARO is performing well using set rules, regulations, and standards of performance.

Demonstrate results

Ministry officials and policy makers are not blind believers in the power of science to solve society's problems. They want to see concrete research results, new technologies based on those results, evidence that the technologies are being disseminated and adopted, and some measure of the final benefits to society. For research organizations to be fully accountable, thereby improving their chances of receiving continued funding at adequate levels, it is imperative that they provide this feedback. Many NAROs are, unfortunately, weak when it comes to marketing their technologies and services, and they don't devote enough effort to demonstrating the benefits of research.

Producing scientific knowledge and new technologies, then, is not enough. It is also essential to understand why and for whom they have been produced and to demonstrate achievements in ways that are meaningful and acceptable to people within and outside the research organization (Gaertner and Ramnarayan 1983).

Benefits assessments and impact evaluations are two ways to build a research organization's credibility. Benefits assessments, carried out before the research begins, provide both researchers and the government with vital information on the potential of a particular project or program to enhance the wellbeing of particular target groups. Impact evaluations, conducted well after the resulting technologies have become available to users, confirm or adjust the initial projections of benefits.

Demonstrating impact, however, is notoriously complex and difficult, mainly because research is not the only force at work in rural development. Distinguishing the NARO's contribution from that of other players and measuring it accurately can be costly and, in any event, is not always feasible. Furthermore, there is usually a significant time lag before the benefits of research take effect and the impact becomes measurable. As time passes, separating out the impact attributable to research becomes even more difficult.

For research products that take a long time to become available to users, NAROs should define intermediate outputs that can be regularly monitored as proof of progress. Users of agricultural technology and policy makers are, in any event, usually very keen to see what research is in progress. It is therefore useful for research directors to be able to show them exactly what innovations their scientists have on the drawing board and what has been achieved to date.

Another way to build credibility with policy makers and government officials, particularly in the ministry of agriculture, is to provide expertise when an urgent problem arises. For example, the NARO can offer its services to help design control strategies for outbreaks of new diseases. Or it can provide concept papers on current issues in agricultural policy. By helping the ministry of agriculture to overcome its own technical problems or by feeding information and insights into the policy-setting process, the research institute demonstrates its competence, gains public visibility, and earns respect.

Improve financial accountability procedures

Public research institutions must account for the funds they receive. This goes beyond the conventional obligation of sound financial management in the sense of legality and regularity. The research manager must establish procedures for financial management and auditing that convince the ministry of finance that the money is in competent hands.

A widespread concern about research programs is whether the funds available were indeed used for the activities agreed upon. Governments and other funding bodies usually know that research programs are rarely implemented in exactly the way they were planned. This is why they want to ensure that research activities are aligned with policies and program strategies.

Fiscal budgets are tight these days and there is a growing trend toward institutionalized evaluation as ingredients of good government and effective public-sector management. In this climate, the financial management and accounting functions in many NAROs need strengthening. Unfortunately, many research institutes cannot quantify how much they have spent on a given research program because their accounting systems are unable to generate this information.

Public research institutes are also well-advised to demonstrate that principles of cost-effectiveness and economy have been applied. They must make their cost structures transparent and ensure that overheads are reasonable. Investors want to fund only good institutions. In cases where governments or donors have been frustrated by a lack of accountability, research managers need to take firm and highly visible action to reestablish the image of their institute.

Managing the Budgetary Process

Budget preparation

The budget process varies from country to country and it is not possible to provide a comprehensive overview. This section will provide some suggestions, however, that should be useful in most situations.

Many different authorities are involved in the budget process. Normally the NARO and/or the parent ministry are responsible for submitting a proposal. The ministry of finance shapes the public budget by imposing expenditure ceilings, reviewing proposals, enforcing priorities, and controlling expenditures. It analyzes economic trends and spending patterns of government agencies and advises the cabinet on appropriate allocations. When all this is done, the budget still requires approval by parliament or some other legislative body.

The allocation of public funds is influenced by all these actors. However, the ministry to which the research organization is attached is of crucial importance. The parent ministry may be the ministry of agriculture or the ministry of science and technology, which covers both agricultural and nonagricultural research. In most budget systems, spending proposals come from line ministries which recommend the magnitude of spending for individual agencies within their portfolios. Similarly, when expenditure cuts have to be made, line ministries recommend the items to which the reductions will apply. Convincing the parent ministry of the importance and relevance of research is therefore crucial.

In most situations, next year's budget will resemble the current year's. Small increases or small decreases are more likely than drastic changes (Caiden and Wildavsky 1980). If a NARO wants a small increase rather than a small decrease, it must use the budget preparation process to promote its research programs and attract financial and political support. This may involve subject-matter arguments as well as strategic and tactical actions by the research leader. Box 3 provides an example of such actions by the Secretary of the Philippine Department of Commerce and Industry (Box 3).

The annual budget request is an ideal opportunity for a meaningful discussion with central government agencies and members of the legislature. The NARO will have more influence over the budgeting process if it credibly presents itself as a purposeful and results-oriented contributor to national goals. To

Box 3. Strategies for Obtaining an Increased Appropriation: The Philippines

- The Secretary of the Philippine Department of Commerce and Industry (DCI) ordered his budget officer to study appropriations of major departments for the previous five years. The aim was to show that his department had been neglected.
- He compared education's budget with that of the DCI (33 percent increase versus less than 1 percent) and argued that the government wasn't letting him create job opportunities for the people it was educating.
- He got the Philippine Chamber of Commerce to support his claim.
- Before he received his budget ceiling, the Secretary addressed a letter to the Budget Commissioner and the Secretary of Finance. It advised them of the new ceiling he expected to obtain (a jump from 8.35 million pesos to 50 million pesos). These were followed by letters and calls to appropriate budget examiners.
- The Secretary also made a series of public speeches and held press conferences to explain the work of the department and to show the need for increased funding.
- When the budget commission told him his ceiling was 10.3 million pesos, the Secretary wrote to them and the President indicating clearly that if the ceiling remained at that level, he would have to resign.
- The Secretary called a press conference and publicly threatened to resign.
- At formal budget hearings before the commission, the Secretary carefully and thoroughly presented his need for the 50 million pesos.
- Individual letters of appeal went to every member of the House and Senate. Booklets describing the need for support were distributed to all legislators. Department teams were set up to persuade individual legislators. The Secretary arranged conferences and meetings with legislators who were invited to address the department.
- The Secretary got advice from "his man" in the budget commission as to how best to present his case:
  a) Make sure bureau heads know their budgets backwards and forwards.
  b) Use charts and graphical matter which tends to channel discussions along desired lines.
  c) Agree to support the President's budget; don't attack it, but be frank about your own needs.
  d) Count on budget examiners for help.
- A revised budget ceiling of 27 million pesos was approved.

Source: Caiden and Wildavsky, 1980.

do this, the budget should be presented in the context of major programs that are fully aligned with the NARO's mission and with national science and technology policy. More specifically, budgeting mechanisms should show what the research organization is or will be doing for different subsectors, regions, or target groups. As such, the budget should clearly indicate how the money being requested will be used, allowing the ministry to verify that planned activities are related to approved policies.

Certain skills and data are needed to prepare a credible budget. The exercise is about specifying *a priori* scientific and technological activities and the resources required to implement them (UNESCO 1984). The budget request is more credible if cost estimates for various programs are calculated in the same way. Standard cost figures should thus be used as much as possible.

It is useful for a NARO to appoint a budget officer to ensure that all formal requirements and deadlines are met. Budget requests should be submitted on time and in the right format. All information therein should be accurate and sufficiently detailed. Inconsistencies in the request may simply lead examiners to cut the budget without judging it on its overall merits. A budget request without formal errors and based on high-quality research programs is less likely to be cut and is much easier to defend.

Some research staff should be involved in the process to ensure that all important items are covered in the budget request. This also helps to give researchers a sense of ownership of the document. In addition, the research leader should monitor the processing of the request, especially to ensure that the parent ministry gets the document to the ministry of finance on time. For more information on budget preparation, see Chapter 14.

Budget justification

The best way for a research leader to defend a budget request is to be fully briefed and have complete and consistent answers to the inevitable queries on program content and usefulness. The answers should give good reasons for not cutting the proposed budget, showing that the benefits of the proposed research exceed the costs.

It's easier to justify a budget request that clearly shows which projects will have to be dropped and which benefits foregone if cuts are made. Assessing such tradeoffs is only possible if the request is based on carefully planned and prioritized research activities and realistic, transparent cost estimates. If, in the end, cuts are made, at least the earlier planning and priority setting will have served to ensure that important areas of research are preserved.

The same logic holds for new initiatives. When public funding is tight and cannot be increased, the NARO will most likely be asked which activity it wants to give up in exchange for the new funding. Preparations to defend the budget must therefore include an analysis of older programs so that it can be determined whether the new activity is more productive.

The size of the approved budget is the result of a multitude of current and past interactions between decision makers and representatives of the NARO.

Research directors cannot, of course, directly control all such interactions. But they can work to improve the motivation, skills, and tools of researchers. A critical asset of the research organization is the confidence that ministries and other stakeholders have in the scientific and managerial competence of the NARO and in the dedication of its staff. The ultimate determinant of public-sector funding of the NARO is whether those who created and nurtured the organization continue to feel it deserves support. It is the research director's responsibility to ensure that they do.

Concluding Remarks

This chapter has shown how research leaders, in an attempt to safeguard their public funding, can take the initiative in four key areas. First, they can make their organizations more responsive to national objectives and the concerns of users through good planning, at both the strategic and program levels. Second, they can garner support for their work through a coordinated communication effort targeted on specific audiences. Here the focus is on productive dialogue with policymakers and telling the institute's story to broader audiences such as farmers and consumers. Third, they can improve the credibility of their organizations by demonstrating that research produces tangible benefits and that money is being spent wisely. Research evaluation and auditing are two key tools for helping the NARO fulfill these accountability requirements. Last, they can improve funding prospects by paying close attention to the preparation and defense of their budget requests.

Public funding of NAROs ultimately depends on the contribution that agricultural research makes to achieving national development objectives set by the government and its ministry of agriculture. Research leaders should be proactive in positioning their organizations to respond to these objectives. They should make sure that research scientists are fully informed of government policy and committed to it. They should also formulate a long-term vision of their organization's role in the future development of the country's agriculture. A strategic plan embodies that vision; it considers stakeholders' needs, reflects government objectives, and anticipates future trends, problems, and opportunities in agriculture. The strategic plan should be widely disseminated as a demonstration of the NARO's commitment to its mission and its responsiveness to public needs. A portfolio of high-quality research programs, for which clear objectives and priorities have been defined using a methodologically sound planning process, is also essential. Well-articulated programs help convince the providers of public funding that the specific research activities to be undertaken by the NARO will indeed lead to relevant and useful results.

A communication strategy is needed to ensure that the research organization transmits a unified set of clear messages about its role and what it hopes to achieve. Communication should be interactive, aimed at both transmitting information about research and absorbing ideas and suggestions for new activities. The strategy should ensure that the right people receive the right message in the language they understand.

But responsiveness to development goals and good communication are not enough. Secure public funding also depends on an organization's credibility. The NARO must demonstrate that it has achieved agreed-on outputs and that the funds provided for this have been spent wisely, that is, in line with public accountability standards. Ideally, the organization should also be able to demonstrate its beneficial impact at the grass roots.

Finally, NAROs should ensure that their budget requests are adequately prepared. Adhering to the norms defined by the treasury and the parent ministry is crucial. The budget request should be submitted on time, in the right format, and without errors in calculation. Once the request has been submitted, the research manager should monitor its progress during the processing stage and be prepared to explain, justify, and, if necessary, modify the initial proposal.

References

Alves, E. 1987. Mobilizing Political Support for the Brazilian Agricultural Research System. In *Policy for Agricultural Research*. Eds. V. W. Ruttan and C. E. Pray. Boulder, USA, and London: Westview.

Caiden, N. and A. Wildavsky. 1980. Planning and Budgeting in Poor Countries. New Brunswick and London: Transaction Publishers.

Collion, M.-H. and A. Kissi. 1995. *Guide to Program Planning and Priority Setting*. Research Management Guidelines, No. 2e. The Hague: ISNAR.

Gaertner, G. and S. Ramnarayan. 1983. Organizational Effectiveness: An Alternative Perspective. *Academy of Management Review* 8:97-107.

Janssen, W. and A. Kissi. 1997. *Planning and Priority Setting for Regional Research: A Practical Approach to Combine Natural Resource Management and Productivity Concerns.* Research Management Guidelines, No. 5. The Hague: ISNAR.

Kotler, P. 1986. *Principles of Marketing*. Third edition. Englewood Cliffs: Prentice-Hall.

Röling, N. 1990. The Agricultural Research-Technology Transfer Interface: A Knowledge Systems Perspective. In *Making the Link: Agricultural Research and Technology Transfer in Developing Countries.* Ed. D. Kaimowitz. Boulder, USA: Westview.

Röling, N. 1992. The Emergence of Knowledge Systems Thinking: A Changing Perception of Relationships among Innovation, Knowledge Process and Configuration. *Knowledge and Policy* 5:42-64.

Smith, P. J. 1994. Identifying Research Priorities in Developing Countries. *Agricultural Systems* 45:455-468.

United Nations Educational, Scientific and Cultural Organization. 1984. Manual on the National Budgeting of Scientific and Technological Activities. Paris: UNESCO.

Recommended Reading

Caiden, N. and A. Wildavsky. 1980. Planning and Budgeting in Poor Countries. New Brunswick and London: Transaction Publishers.

This provides a comprehensive discussion of the subject with examples and illustrations of budgeting procedures. The text includes an analysis of the budgeting process from the perspective of a ministry of finance as well as that of a spending agency.

Gaertner, G. and S. Ramnarayan. 1983. Organizational Effectiveness: An Alternative Perspective. *Academy of Management Review* 8:97-107.

An approach to examining organizational outputs and processes in a critical and holistic way is presented. The text suggests a framework that views effectiveness as the ability of an organization to account successfully for its outputs and operations to its various constituents.

Ruttan, V. W. and C. E. Pray. (eds.) 1987. *Policy for Agricultural Research*. Boulder, USA, and London: Westview.

This collection of papers analyzes crisis, organization, and reform of agricultural research systems in the U.S. and in developing countries. It also contains U.S. and Brazilian case studies on mobilizing support for agricultural research.

UN Department of Technical Cooperation for Development. 1987. Planning and Control of Public Current Expenditure: Lessons of Country Experience. New York: United Nations.

The report provides an analysis of experiences in applying various methods of financial control of public expenditure. The text also highlights some theoretical issues and the problems that arise in the process of reshaping public expenditure.

United Nations Educational, Scientific and Cultural Organization 1984. Manual on the National Budgeting of Scientific and Technological Activities. Paris: UNESCO.

The manual sets out the budgetary methods, procedures, and instruments needed for preparing a science and technology budget. It looks at the conceptual and operational framework of science and technology budgeting and the main government decision-making processes. It describes the various operations required to program for science and technology in a multi-year perspective that links up the plan and the budget.

Chapter 10 How to Mobilize Donor Funds

Marian Fuchs-Carsch

Introduction

This is a practical "how to" chapter designed to help agricultural research leaders obtain external funds. It assumes that the NARS already has an adequately trained staff whose salaries are paid by the national treasury. But it also assumes that the NARS lack the funds needed to undertake a vibrant research program—one whose results would help farmers improve their output and family incomes and help decision makers set policies that improve overall economic returns to agriculture.

The rest of this chapter is divided into five sections. The first provides background on donors. It identifies different sources of external funding and provides an overview of the main funding agencies. The second discusses aspects of making contact with donors. Advice on preliminary donor relations is followed by a discussion of the types of external aid normally available for NARS research. The third section provides detailed suggestions on how to design projects and write them up for submission to donors. The fourth is about maintaining good donor relations. A discussion of the "strings" attached to some grants is followed by suggestions on how to maintain good relations once a grant has been received. The final section presents some concluding remarks.

Background on Donors

Where does the money come from?

Nearly all overseas funding for agricultural research in developing countries comes from public sources. While private multinational corporations undertake research on a range of tropical commodities—pineapples, bananas, and coffee, for example—this is done to support the commercial export side of production. Research aimed specifically at subsistence agriculture and poor farm families with small holdings is rarely if ever profitable for multinationals and other private companies.

Thus, it is the taxes paid by millions of people all over the world that are the ultimate source of external funding for agricultural research in developing countries. It is surely one of life's ironies that people who have never visited a developing country or even heard the name of its capital city often provide the funds that lead NARS scientists to develop a better-yielding maize plant, a more energy-efficient water pump, a new way of raising fish in rice paddies.

Taxpayers in industrialized nations are also voters. They elect the politicians who make the decisions to spend some of their national budgets on overseas R&D. If those voters are angry with their politicians, because their own incomes are declining, for example, they will put pressure on the politicians to spend less on projects overseas, and more at home. When parents worry about their own jobs and those of their children, they do not feel they can spare money for families in poorer countries. In this context, it is important to recognize that today it is harder to mobilize resources than it used to be. This is true for research systems in industrialized countries, too. Scientists everywhere are learning that they cannot expect their institutes to automatically provide them with research funds and that they need to write proposals to secure outside funding for specific research activities.

How funds are channeled

In general, a NARS director or scientist will need to go through a government ministry to get external funding. In most developing countries, the government has designated a single ministry—of external affairs or cooperation, for example—to coordinate the receipt of donor funds. This ministry accumulates the requests of all government agencies and, guided by national priorities, negotiates with donors on the terms and allocation of funds.

The importance of having good relations with officials in the ministry cannot be overstressed. There may be some opportunity for direct negotiations with donors, especially foundations and nongovernmental agencies, and with those government agencies that maintain national offices. But in most cases, agricultural research is competing with many other sectors (transport, energy, education, and environment, for example) to get to the top of the nation's wish list.

The rest of this section provides information about the various donor agencies through which the taxes paid by developed-country workers are channeled to developing countries. Such information can help NARS directors and their ministries of cooperation to address the right donor agency.

Multilateral donors

Multilateral donors are ones that draw their funding from many countries. Most are development banks or UN agencies.

The biggest of the development banks is the World Bank. Based in Washington DC, it has offices in many of the larger countries to which it lends. The World Bank, sometimes known as the International Bank for Reconstruction and Development (IBRD), provides loans on various terms. To countries with low per capita income, it provides "soft" loans from a subagency called the International Development Association (IDA). These loans have low rates of interest, grace periods (the initial period during which no interest is due), and long repayment periods. In some instances, though rarely, the World Bank provides grants.

In 1994 the World Bank instituted a US$500 million program specifically offering soft loans for agricultural research in developing countries. It was made a loan program to ensure that recipient governments recognize that agricultural research yields economic returns as attractive as those from the infrastructure and energy projects for which governments usually request loans. It is important that NARS leaders support the Bank's intentions by making the same case to their ministries of cooperation or external affairs.

The lending of the World Bank is supplemented by funding from the regional development banks. The African Development Bank (AfDB), based in Abidjan, Côte d'Ivoire, provides development loans to all the countries of continental Africa, including those that are sometimes seen as part of the so-called West Asia and North Africa region.

Countries in Latin America, from Mexico to Argentina, plus the Caribbean nations, are eligible to receive funds from the Inter-American Development Bank (IDB). Although IDB is based in Washington DC, it has branch offices in all major recipient countries.

The Asian Development Bank (ADB) has its headquarters in Manila. It provides financial support for countries from Afghanistan to the South Pacific islands. ADB also provides financing for new countries in central Asia, such as Tajikistan and Turkmenistan.

The newest regional development bank is the Paris-based European Bank for Reconstruction and Development. It was set up to provide financing for the newly emerging countries of Eastern Europe.

There are a number of multilateral sources of funding for the Middle East region. The Islamic Development Bank supports Arab countries and those with Islamic majorities, such as Pakistan and Indonesia. The Arab Fund for Economic and Social Development, however, supports only countries whose citizens are Arab.

While the development banks are divided by region, the **United Nations agencies** are divided by function. There are specialized agencies for children (UNICEF), science and culture (UNESCO), labor (ILO), health (WHO), environment (UNEP), and many other areas. The Food and Agriculture Organization (FAO), based in Rome, supports agricultural development, including research. The specialized UN development agencies, however, are not directly funded; they receive their budgets from their parent agency, the United Nations Development Program (UNDP). UNDP makes some direct grants itself and supervises grant allocations to development projects from specialized funds including the new, large Global Environment Fund, the loan component of which is administered by the World Bank.

Multilateral donors take in funding contributions from various countries. In recent years, several countries, most notably the USA, have cut their supply of funds to multilateral agencies, saying that they are inefficient and wasteful. Management changes at several UN agencies and several development banks have started to persuade industrialized countries that they should once again start funding multilateral organizations.

There are UN offices in most developing countries, and NARS leaders are encouraged to visit these. They are staffed by international civil servants from both South and North. Overseas UN offices are headed by a resident representative, whose parent organization is UNDP. In the UN buildings, there are FAO offices, which can provide valuable technical information and contacts, and possibly financial support.

The European Union (EU) is one of several **other sources** of multilateral funding for international development. It obtains its funds from its member countries and provides grants and loans throughout the developing world through different directorates. One directorate focuses mainly on the countries of Africa, the Caribbean, and the Pacific, under a set of rules known as the Lomé Convention. Other countries receive funds under a less centralized system. EU funding for agricultural research is increasing, and is definitely worth seeking. But the bureaucracy is strong, and NARS need patience in pursuing these funds.

Middle East oil money, coupled with sources from the industrialized countries, has been channeled to development and research projects throughout the world's poorer nations through the International Fund for Agricultural Development (IFAD), based in Rome. IFAD has a special interest in poverty alleviation. Since the price of oil has declined, IFAD does not have the resources it once did. However, since it is exclusively focused on agricultural development, it is worth learning about IFAD's work in any given country.

Bilateral donors

Bilateral donors are those with a single source of funding. Most of them are individual national governments that offer grants and loans to other governments to undertake development or research activities. Nearly all the industrialized countries have bilateral programs or agencies that support agricultural development in poorer nations. Unlike most multilateral donors, bilateral donors usually give grants for agricultural research.

These donors are quite different from each other when it comes to funding levels, requirements, and areas of interest. Some donors prefer to work in certain countries or regions, perhaps for reasons related to their colonial past. Others have special subject interests. Donor interests, needs, and budgets are subject to rapid change, as has been noted elsewhere in this chapter. Box 1 provides a very brief introduction to bilateral agencies.

Box 1. Major Bilateral Donors and Their Principal Interests

Australia, via AusAID. Particular interest in Asia, especially relatively nearby countries such as Papua New Guinea and Indonesia. One of the few countries to increase its funding for agricultural research, thanks to a vibrant public awareness program targeted on Australian voters.

Belgium, via BADC. Limited funds, but steady supporter, especially in former colonies. Interests include both livestock and crop projects.

Canada, via CIDA. Consistent supporter of agricultural research and important in many countries. Strong social and environmental concerns. Canada also supports a public corporation called the International Development Research Centre (IDRC), which provides small grants in various areas of research for developing countries.

Denmark, via DANIDA. Special interests include dairy farming and natural resources. Operates in a limited number of countries. Consistent donor once committed. Funds have increased in recent years.

France. Funding increasingly channeled through technical agencies such as CIRAD and CEMAGREF. Particular interest in the poorer parts of francophone West Africa, although growing linkages with agricultural research in Asia and Latin America.

Germany. Funds allocated through BMZ, the Ministry for Economic Cooperation. Technical agencies provide substantive review: GTZ in international development; ATSAF in research appraisal and information; DSE in training, dialogue and communication; KfW in capital projects. Germany funds a wide range of agricultural research throughout the developing world.

Japan, via JICA. Prefers to support research in Asian agriculture, although support is increasingly being given to projects in other parts of the developing world. Despite recent financial constraints within the country, the level of funding support should continue to increase.

Netherlands, via DGIS. Consistent donor, with a strong interest in natural resources and social issues. Has a "spearhead" program in research, and supports countries in all parts of the developing world. Recently decentralized much project decision-making, giving authority to officers based in embassies.

Norway, via NORAD. Strong interest in social issues and the environment. Small grants approved locally by NORAD officials based at Norwegian embassies.

Sweden, via SIDA. Support for agricultural research used to come through SAREC, a separate agency. SAREC has been folded into SIDA, one manifestation of recent Swedish budget cuts. Strong interest in Africa and in the poorest of poor beneficiaries.

Switzerland, via SDC. Special interest in mountain agriculture, livestock, and training.

United Kingdom, via ODA. Provides funds throughout the world, for a wide variety of agricultural activities. Increasing emphasis on natural resource management.

United States, via USAID. Support for development and research is currently highly unpopular with politicians in the USA. Future of USAID is highly uncertain. US Department of Agriculture (USDA) has small overseas program.

Private sources: foundations and NGOs

A number of foundations in the United States provide grants for agricultural research. These include the Ford, Rockefeller, Kellogg, and MacArthur

Foundations. These organizations were started with funds from corporations or wealthy individuals. As they have far fewer employees than other donors, they usually cover fewer countries and types of projects. They are a good source of quick funding in relatively small amounts—for instance, for sending scientists to international conferences or for specialized training. But they also provide grants for longer-term projects. Information on these groups can be obtained from USAID offices or US Information Offices which can be found in the capital cities of most developing countries.

There are similar foundations in Japan, in particular those started by large firms such as Toyota, Mitsubishi, and Honda. More about these foundations can be learned from the Japanese embassy in a given country.

Germany has a number of "Stiftungen" supported by its three main political parties. These were more important sources of funding in the past than today. Information on these foundations can be obtained from local German embassies or offices of the Goethe Institute.

Several large nongovernmental organizations (NGOs) operate in the agricultural sector and may be a source of funds for research. Some are international, like Save the Children, CARE, Bread for the World, World Vision, Oxfam, and Christian Aid. Some are national, such as the Grameen Bank and Proshika in Bangladesh.

Each NGO has its own particular interests, and NARS leaders will need to make a "research project" of getting to know their local NGO community. This is likely to be a useful and interesting undertaking, since NGOs have much to offer in addition to being a potential funding source. They often have technical and managerial know-how and international experience to share and transfer. They can also provide important contacts around the world.

Who controls the donations?

Most of the donor agencies described above have policy-setting boards and staff who program the funds (i.e., justify the allocations). Typically, the staff of donor agencies prepare proposals which they then submit to their boards for approval. In the case of bilateral country donors, loan and grant approvals may be made by politicians or by senior civil servants who may be political appointees.

What motivates donor staff?

Although all donor agencies employ some technical specialists, most decision making at the staff level is by generalists. When approaching donor agencies for funding, it is useful to keep in mind what motivates agency staff. Here are some of the more common motives:

- spend taxpayers' money wisely by identifying responsible fund recipients to avoid waste and corruption;

- achieve annual funding targets (i.e., move the money as quickly and efficiently as possible);
- ensure that fund recipients are spending the money as quickly as originally intended and for agreed-on purposes;
- allocate the money to activities that show results and help the largest number of people and/or the neediest.

Donor agencies will also want to address their special interests. As noted above, each has its own preferences. The Scandinavian donors, for instance, all tend to have a special interest in projects with a strong social or environmental approach. The US and UK like projects that emphasize the role of the private sector. IFAD is most interested when the very poorest segment of the population will benefit.

Donors need to be sure that their projects are national priorities. Their main source of information will be the staff of the ministry of planning, cooperation, or external affairs. But they will also want to hear the views of technical people, like NARS leaders. They will likely solicit the views of beneficiaries, either individually or through NGOs and other grassroots groups, to ensure that they, too, are enthusiastic about what is planned.

Most donors like to see their funds leverage greater funds from another source. All want to avoid supporting those projects that will collapse once the funds have been expended. The hope is that once donor support has shown the value of a particular activity or approach, the host country will "institutionalize" the project by putting its operational costs into the national budget. Failing that, donors like to see other donors interested in funding follow-on phases. Support from one donor, therefore, often begets additional funds from others.

Making Contact with Donors

Getting to know donors

Even though NARS leaders may need to go through their ministry of cooperation when applying for donor funds, it is most useful for them to develop good relations with as many donor agency representatives as possible. This section provides some suggestions.

The NARS leader should initiate the relationship with a visit to the donor's office. The purpose should be to extend an invitation to the donor to visit NARS projects so as to learn more about the research programs and priorities. The NARS director may wish to give an assistant special donor-relations assignments. For example:

- establish and regularly update a donor mailing list;
- send frequent pieces of news, including success stories and publications lists;

- set up a donor library containing brochures, notes about meetings, correspondence from donors, and project proposals;
- prepare promotional materials, such as brochures, fact sheets, slide presentations, and videos;
- invite donors to seminars, farmers' days, professional meetings, and social events.

It is important to establish a relationship with the donor before making any financial or other requests. Box 2 provides advice on making presentations to donors.

Box 2. Tips on Making Presentations to Donors

- Take a colleague along to give the audience a chance to see more than one NARS representative, and to balance the presentation. A male director could be accompanied by a female scientist, or an older director by a younger colleague. Both should be involved in the presentation and/or the subsequent discussion.
- Nothing is more infectious than enthusiasm. Short sentences, delivered quickly, convey an urgent message. So do people who lean forward and look their listeners in the eye.
- People remember real life examples better than abstract ideas. Donors are interested in the impact of research: who is better off as a result of NARS research?
- Referring to other researchers and to key government officials in a presentation will give the donor confidence that a NARS leader is well-regarded and enjoys the confidence of senior government officials.
- It is usually safer not to sing one's own praises, but to let the facts speak for themselves. A NARS leader can discuss staff qualifications, the number of scientific papers published, the number of farmers who have been helped, the number of grants already received, and the quality of the equipment on hand. But sentences like "we do thorough, careful research" are to be avoided. Let the audience deduce the quality of the research organization's work from the words of its leaders, what its clients say, what they read, and what they see when they visit the field.

Less donor money and more competitors

Agriculture is not a popular subject with donors these days. Its heyday was in the 1960s, when the specter of famine mobilized large sums of money for agricultural research. There is now a feeling that the world can grow enough food to feed today's population, and even tomorrow's. This argument holds that the problem is one of economic policies and distribution, not of lack of knowledge about how to grow enough food.

In many countries, agriculture declines in importance as development speeds up. In countries where per capita income is rising sharply, including Malaysia, Thailand, China, and many Latin American nations, farm families are leaving the rural areas to seek an improved life in the cities where they hope to work in industries or services. This phenomenon encourages donors to focus on facilitating the transition, rather than reversing the trend.

Also, in the post-Cold War period, the need to mitigate the effects of an unprecedented number of international disasters, both natural and of human making, have absorbed huge sums of donor funds originally earmarked for research or development. Feeding and otherwise taking care of the refugees of Angola, Liberia, Rwanda, Somalia, Yugoslavia, among many others, has taken billions of dollars for one-time relief efforts.

So there are fewer funds for research and development and an increasing number of demands. Agriculture must now compete with other sectors and socioeconomic issues, many of which have attracted worldwide interest through global events like the Earth and Social Summits.

Packaging

Everyone in business knows that packaging sells the product. Toothpaste is a useful item, but it is the tube that delivers it to the toothbrush. A product like jam can be sold for a higher profit margin if it is in an elegant jar with a fancy picture on the label.

Agricultural scientists, too, can package their activities. It is often a matter of presentation. For example, imagine a project that seeks external funding to do research to increase the productivity of fruit trees in a given country. Here are some of the ways that research and its impacts can be packaged for different readers:

- For a donor interested in the environment, stress that the trees, if introduced in the upper reaches of a watershed, will help prevent erosion and aid soil fertility.
- For a donor interested in economic growth, explain how the trees will provide long-term income for relatively low labor inputs, freeing up family labor for other, possibly higher-income activities.
- For a donor interested in nutrition, show how fruit is an ideal source of vitamins in a high-starch, low-protein diet.
- For a donor with social interests, explain how tending fruit trees is an occupation that allows women and children to participate in the economic life of the family.
- For a donor interested in capacity building, show how support for the project will help to build the horticultural research capacity of the NARS.

Endorsements

In television advertisements, products are often sold by showing their use by famous and attractive people. NARS can make their research attractive by getting written endorsements from planning division personnel, senior policy makers, politicians and/or prominent scientists. Such endorsements may be in the form of quotes in a speech or proposal, or in separate letters or other communications directly with the donor.

Endorsements from beneficiaries may also help—if they are the right beneficiaries. In the above example, a visit by a delegation of rich fruit farmers would not be a good idea, because donors are not interested in their funds going to segments of the community that are already favored. But a petition signed by an association of small-orchard owners, requesting the donor to support this project because of the benefits it would bring to the membership, would be useful. It would help the donor to decide between this proposal and a competing one that did not have such an endorsement.

Requests for proposals

It should be remembered that both sides are searching in the donor relations business. The donor is looking for a good project or organization in which to invest; the organization or project is looking for a source of funds. The paragraphs above gave suggestions as to how the NARS leader could initiate the relationship. Sometimes things work the other way round.

When the donor agency knows which kinds of projects it wants to fund, it may issue a request for proposals (RFP). In this instance, the donor is looking for as many project ideas as possible, in order to choose the best. A prospective recipient group must bear the cost of preparing the proposal, knowing that others will also be doing the same. There are not many RFPs for agricultural research, but there are some competition-based sources, such as the ODA's Holdback Facility and the EU's Technical Cooperation Program. NARS leaders may wish to explore these by contacting the local British Embassy or European Community Office.

Sole-source proposals

Money should not be the subject of early interaction with a donor agency. However, by the second or third meeting, it is quite appropriate for a NARS leader or scientist to ask if the donor would consider receipt of a written proposal, and if so, when. As noted later, each donor has a funding and approval cycle that needs to be taken into account. If the donor is willing to consider a proposal at a given time, this constitutes an invitation to prepare a sole-source proposal, i.e., a proposal to undertake something that cannot be equally well done by others.

What kinds of support can a NARS ask for?

Donors do not only make loans and grants. They may also pay for services, i.e., contract with a NARS to provide a specific output. They may also provide equipment, training, or personnel. In a sole-source proposal, it might be wise not to ask for a foreign currency grant, unless this is absolutely essential, e.g. to fund an external consultant or imported equipment. Many donors find it easier or preferable to provide local currency grants, to second young people to help, or to donate equipment.

Financial arrangements

Donors provide loans, grants, and contracts. Loans may be hard, (at or near commercial interest rates) or soft (at lower interest rates and with more generous grace and repayment periods). Some donors, especially the development banks, prefer loan programs. First, they see government willingness to repay the money as an indication that the project is a priority. Second, the repayment funds can be recycled to support additional activities.

In the 1990s, there has been a strong move in the donor community to substitute soft loans for grants for the funding of national agricultural research. Nowhere is this more clearly seen than in the World Bank, which has set aside $500 million for developing countries to tap for NARS activities.

There are many different kinds of grant arrangements. As indicated, they may be in foreign exchange, local currency, or a mix of the two. Grants can also be in kind; the World Food Program, for example, often uses food as the currency of its grants.

Donors may contract for specific services or products. Quite often, donors wish to associate national agricultural research organizations with projects being implemented by contractor teams. This may be done by a host-country contract directly with a local organization, or through a subcontract. Contracts may be with a given organization as a whole, with a given department or section, or with individual researchers.

Nonfinancial arrangements

Many donors like to foster technical or professional linkages between NARS and research entities in their own or other countries. Such linkages are likely to be in the NARS' interest, not least because the scientists in those other research institutions can provide endorsements and donor contacts for the funding of future projects. Several donors also offer training opportunities which NARS leaders can use to strengthen the capacity of their staff, and as rewards for the best performers in their agencies.

Some donors like their funds to be applied to the purchase of equipment produced in their home country, which is then used by the NARS in the project under consideration. Provided this equipment is compatible with what is already on hand, and that the need for future spare parts and maintenance is accommodated by the grant, this can be a useful way to upgrade the NARS labs, computer facilities, motor pool, etc.

A few donors will want or offer to post their own scientists to work alongside NARS scientists. NARS leaders may feel that the large amount of money needed to support expatriate scientists would be better spent on additional research work. However, it should be remembered that seconded scientists often come with small research budgets, and they nearly always come with bright ideas, enthusiasm, and useful professional linkages. They can also provide a good communication channel with the donor for future funding requests.

Grant sizes

Most donors have upper and lower limits on grants. A small grant may require as much paperwork and consultation with headquarters as a big one; for this reason, many donors will not consider grants below a certain level. Some donors, especially those that have decentralized some decision making to the field (for example, the Ford Foundation, USAID, and some IDRC and ODA offices), can approve relatively small proposals in the field, but have to send larger ones to headquarters. This obviously makes a difference to a NARS if it is seeking a quick injection of funds—for example, to support a scientist with a sudden opportunity to study abroad.

Since the budgets of all donors fluctuate from year to year and place to place, the only way to find out about the grant limits imposed by individual donors is to ask. It is a legitimate question to which NARS scientists need an answer in order to prepare a sensible proposal. Donors will not hesitate to provide this information.

Budget restrictions

Most donors have precise rules on what they will or will not fund. For instance, some donors will not pay salary toppings or honoraria; others will. Some donors are very concerned about indirect costs (discussed in a later section). Some donors want very detailed budgets, and will question every line item; others are much less demanding. Only experience and discussion with donors will provide such important information.

Grant duration

Almost all donors work on annual budget cycles. The most "political" donors (bilateral agencies of industrialized countries) have budgets that may fluctuate considerably. Few donors are therefore willing to make long-term commitments, even when they recognize that the subject matter, such as agricultural research, demands it.

Most donors are used to funding three-year projects, with five years as the usual outside limit. If a NARS scientist knows the proposed work will take longer, it is recommended that the work be presented in phases, ideally three years each. The original proposal should state explicitly that a follow-on grant will be needed if phase-one results indicate the work should be continued. Most donors find it easier to finance follow-on grants than initial grants since they already know the recipient NARS and are anxious to protect their original investment. If phase one went well, the chances of getting phase-two funding are much higher than if a new proposal is submitted to a new donor.

By phasing project activities, it may be possible to secure funding for a single project for as much as 10 years. But this cannot be guaranteed, and the wise NARS leader will always be thinking ahead to ensure seamless funding for long-term research.

How long will it take to get a grant?

There are at least four stages in turning an idea into a fully funded project:

- **Project design and proposal preparation.** This stage comprises all the steps in converting an idea into a proposal ready for submission to a donor. It is the subject of the next section of this chapter. Depending on the scale and complexity of the project and the number of people involved in the design, this stage may take as little as a month or more than a year. There is a growing trend to involve beneficiaries in project design to ensure their full cooperation during implementation. This, of course, prolongs the design phase, but early implementation will be surprisingly fast, and the results should be superior.
- **Internal approvals and clearances.** The NARS proposal will need to be cleared internally by the host government. This is where the NARS director's contacts with the various powers-that-be in his or her government are all-important. If relations are good, approvals can take anywhere from three to nine months. Without any clout in these offices, approval may take over a year. The wise NARS leader will involve key individuals from the planning, cooperation or external relations ministry in any plan to seek external funding. It is important to secure an initial expression of support from these people before time and money are committed to the preparation of a proposal.
- **Consideration by donor.** Once the responsible host-government body has submitted the proposal to the donor on behalf of the NARS, it is the donor's turn to obtain internal approvals and clearances. As already noted, if the grant is relatively small, approval can be given locally and may require only one or two months, especially if the NARS has been maintaining regular donor contact. However, for a large grant, the donor will probably have to send the proposal to headquarters, perhaps for submission to a board that only meets at certain times of the year. So initial donor approval of the grant may take six months or even longer.
- **Negotiations.** A donor will often approve a proposal in principle but have serious questions about some of the planned activities or items in the budget. At this point, the NARS and the donor need to negotiate. If the issues of concern are simple and the donor has a staff member in the host country with full authority to negotiate, this stage, if it happens, may take as little as a month. If the issues are complex and negotiations require headquarters approval, this stage can stretch out to three to four months.

The various stages add up. It takes at least five or six months from idea to funded project, with an average of 12 to 18 months. In some cases, up to three years may be needed. Patience is an essential quality in external fund-raising.

Project Design and Proposal Preparation

The art of converting an idea into a project with outputs and impact is as old as civilization itself. It is indeed an art, and as such, there is no single right way to do it. What follows are suggestions for efficiently turning an idea about agricultural research into a project described in a proposal to an external donor. It is a logical progression of steps that has proved successful for others.

Screening research ideas

In most NARS, there must be dozens or perhaps hundreds of ideas for research stirring in the hearts and minds of scientists. It is the research leader's task to find the best ones. In terms of donor-fundable projects, the "best" ideas are those that meet all the following criteria:

- They are of interest to all parties: researchers, beneficiaries, politicians, and the donor.
- They are researchable within a reasonable time span.
- They do not cost more than is likely to be available.
- They can be implemented by available human resources (including additions funded by the project).
- They are worthy of research, i.e., have the potential to make an important difference.

It is not the task of this chapter to advise NARS leaders how to make these decisions. However, it should be noted that, increasingly, donors are supporting only research projects that show promise of direct and positive impacts on the lives of poor people. Proposals most likely to receive funding will be for research that can bring about positive changes in one or more of the following: the health, wealth, nutrition, and general well-being of farmers and their families; the state of the environment (land, watershed, etc.); national food security; economic growth. In the 1990s and beyond, research that produces knowledge for its own sake is unlikely to attract donor funding.

Preliminary design: Preparing a concept paper

Once there is agreement that an idea is worth developing, it is advisable to do the preliminary design by preparing a short concept paper (CP). This can be written by the person whose idea it was, but it might be better to set up a small design team to work together on developing the concept. Box 3 provides a sample outline for a one- to two-page concept paper.

Box 3. Sample Outline for a Concept Paper

Working title
Objective
Proposed site(s)
Proposed staffing
Collaborators and partners
Project duration / start date
Estimated cost
Possible donor(s)
Goal and purpose (one paragraph)
Relation to institute's program (one paragraph)
Expected outputs and impact (two to three paragraphs)
Proposed activities (two to four paragraphs)

Once finished, the CP should be reviewed at a formal meeting within the institute, with scientists from different disciplines invited to the review. The institute director is the ideal person to chair the review.

At this point, it is useful to share the CP with one or more potential donors, to determine what interest there is in supporting it. This may also be a good time to discuss the proposed project informally with contacts in the ministry of cooperation. If problems crop up at this stage, the project can be canceled or shelved before too much time, effort, and love has gone into its design.

Full design: Harnessing logic and imagination

If a donor has shown preliminary interest, if everyone in the NARS is happy with the concept, and if indications are that the planning division will agree to sponsor the project as a government priority, the scene is set for full project design.

There are many ways to design research and development projects. One of the most widely used is the logical framework matrix (Horton et al. 1993). The recommended reading list at the end of the chapter also provides references helpful in project design.

Project design is an act of imagination. The designer tries to imagine what inputs will be needed to achieve the desired effect, in what combination, where, when, and at what cost.

One useful technique for people with limited experience in designing projects is to brainstorm in a group, taking each section of the project proposal and discussing alternative combinations until a consensus is reached. An ideal brainstorming group will consist of three to five people from different disciplines (one agronomist, one biological scientist, and one economist, for example). The disciplinary mix will enrich the design process.

Another useful exercise is to examine an earlier project that is known to have been highly successful. The design team can analyze that project, identify elements that made it succeed, and incorporate them into the design of the new project.

If possible, the design team should seek informal inputs from outside reviewers as the design progresses. Outsiders can sometimes pick up on simple things that team members cannot see because they are too close to the project.

In some countries, the government may have a set format for presenting proposals to external donors. If so, the NARS should use it. Annex 1 describes one specific method, based on 10 steps, for presenting proposals in a logical, easy-to-read fashion. It has been successfully used for international agricultural research projects. It is certainly not the only method, but NARS leaders may wish to adapt it for use in their institutes.

Moving the proposal through the bureaucracy

Once the proposal is written, it is up to the NARS leader to shepherd the project proposal through the national government's bureaucracy. Since each bureaucracy is different, it is not feasible here to give highly specific suggestions. In general, however, lobbying and face-to-face meetings give proposal reviewers a better chance to understand and support the project. Informal presentations, as well as endorsements from colleagues, superiors, and illustrious scientists, are also helpful. In fact, an interested donor representative may be willing to speak on behalf of the project at this stage.

Proposal revision

Project designers should not be surprised if they need to revise the proposal several times. As noted earlier, all stages of project development tend to drag on, and as time passes, circumstances change. Assumptions made during the preparation of the concept paper may no longer be valid two years later when the full proposal first goes to the treasury or the donor's headquarters.

If the project is large and complex, the design team will almost certainly be asked to revise the budget, and perhaps to cut down the scope of the activities or make the objectives less ambitious. A donor may also ask for other sites to be added or for the project to be merged with others in which the donor is interested. If the NARS project designers are open and flexible, this stage of project development can be seen as an opportunity to improve the design, rather than as a delay in receiving the funds.

On-Going Donor Relations

Donor "strings": The quid pro quo

Few donors provide money for purely altruistic reasons. As organizations, donors often have policies and preferences that have a direct bearing on how a

NARS can spend the money it receives. The regional development banks all require their funds to be spent in the region they cover. But some are stricter than others. The Inter-American Development Bank, for example, will not allow its funds to be used to cover the costs of any consultants or staff who are not from member countries.

Some donor countries refuse to invest in particular developing countries for political reasons stemming, for example, from a recent diplomatic dispute, a history of military conflict between the two countries, or an unacceptable human rights record. Countries torn by civil war may attract relief funds, but in the absence of at least a small measure of political and social stability, donors prefer to hold off investing in research and development projects.

There are often sourcing limitations. Many donors have complex procurement rules that need careful study by prospective recipients of funds. In particular, bilateral agencies usually want grantees to buy goods and services from the donor country if items are not available locally. Seeing that some of the donor money is recycled back to the domestic private sector helps to make foreign assistance more popular with donor-country taxpayers.

Many, if not most donors, impose programmatic restrictions on funding. Some Scandinavian donors will not fund anything that might have a negative environmental impact, even if the other outcomes are positive. Many Western donors like to see provisions for the private sector to take an active role in the project, perhaps as consumers of research results. Proposal writers need to understand the likes and dislikes of each donor, and work around these.

All of this means that there will always be some quid pro quo in accepting grant funds from an outside source. Some of the strings attached to the money will pull tighter and seem more uncomfortable than others. Everyone knows of the short-term hardships associated with structural adjustment programs required by the World Bank for the receipt of its funds in many countries. Looked at from one perspective, strings can be used to the NARS' advantage: donor pressure may help a grant recipient to introduce unpopular but useful measures.

The prospective recipient always has a choice, of course. If a NARS cannot accept the donor's restrictions, it need not accept the money. It can always look elsewhere. Although it does not always seem so, the scarcity of well-designed projects is usually greater than the scarcity of donor money.

After the grant is received

Assume that the years of project design, proposal writing, and waiting have paid off and that a NARS has succeeded in obtaining a grant from an external donor. The story doesn't end there. The NARS leader must now consider three things: the extent to which the donor will want to be involved in the project; the need to keep the donor interested so that a follow-on grant can be obtained if necessary; and, if several donors are involved, how to coordinate the various separately funded activities.

Donor involvement

Donors vary widely as to their interest in, and capacity for, involving themselves in the implementation of a NARS research project. Those with no country field offices will obviously be less involved and intrusive than those with technical staff and vehicles in the country.

Some donors see their role as mere providers of money. Others see themselves as partners, with expertise to share as well as money. On first reflection, it might seem that the far-away donors are the "best." After all, they are out of sight and will leave the NARS to do its own thing. But sometimes a donor that cares about details can help redirect a project that is limping along because external conditions have changed, key individuals are being difficult, or the design was too rushed, too simple, or too optimistic. Wise NARS leaders will keep an open mind. They will share their concerns, needs, and fears with the donor, and use the donor's different strengths and influence to help them achieve their aims.

All public bilateral donors are held accountable to their own treasury or finance ministry for the funds they grant. Increasingly, grants and loans are monitored during their implementation and audited or evaluated at mid term and after completion. The people assigned to carry out these tasks may be from separate agencies, with little interest in the country or subject matter. They may be inspectors, trained to be skeptical and suspicious. Having to respond to such audits and evaluations is one of the strings often attached to donor aid.

Keeping the donor interested

There is much to be gained by maintaining good relations with the donor throughout the implementation of a project, not least to ensure receptivity to future needs. Good grantees send their project reports on time and invite donors to key project activities. They send newsletters and encourage suggestions.

Donors also appreciate NARS leaders who keep track of changes in the domestic environment of the donor country. If the economic situation worsens, donor representatives are likely to be put under stress, fearing budget cuts or even staff reductions. In addition, political changes can have sharp effects on funding policies. NARS leaders will reap rewards in many ways by keeping abreast of the context in which their donors must work.

Minimizing work and overlap

Managing donor funds can be labor-intensive. Some donors need far more detailed accounting for funds expended than others. It is important to discuss this with the donor *before* the project budget is finalized. If very strict accounting is to be required, funds for a full- or part-time accountant should be included in the supplies and services line item of the project budget. That way the donor agency pays to get the accounting accuracy it needs.

If a NARS has activities sponsored by several donors, it may be worth the effort to try collective project monitoring, reporting, and evaluation. A NARS leader wanting this type of coordination needs to take all donors into his or her confidence and invite them to form a group. The NARS leader may suggest that reporting and accounting be streamlined into a single format. Donors will generally be sympathetic, and will comply if their rules permit.

It should be noted that in some countries, such as Bangladesh, Kenya, and Nepal, donors are assigned specific provinces in which they "specialize." In this situation, it would be sensible for the NARS to select research sites within the geographic areas assigned to those donors that have a stated interest in the subject covered by the research proposal. It would also be sensible to try to coordinate the proposed research with work being done by other government agencies in a given province or region.

In general, NARS leaders can learn much about donor relations by speaking to other organizations that have had experience with particular donors. As funds become increasingly scarce and competition for them grows, the rules and regulations are becoming more and more complex and onerous. No one should be ashamed to ask for outside help and advice.

How to be a happy (and successful) fund-raiser!

Most NARS leaders probably never expected to become fund-raisers when they first decided on agricultural research as a career. And many, finding they have to do it, don't much like it. Most NARS leaders would rather be doing, managing, or evaluating research. Here are some tips to help NARS leaders enjoy this necessary part of their work and get better at it.

- **Regard a fund-raiser as a facilitator, not a beggar.** As noted earlier, the art of project development is to match the donor's desire to invest in a good project with the recipient's need for funds to undertake research and development. This "match making" requires special skills, especially brokering, and is definitely not begging. It is a legitimate and important part of the NARS leader's job, and he or she will receive praise for doing it well.
- **Be prepared for rejection.** No one can get every single proposal funded. If a donor turns down a proposal, a NARS representative should try to find out why, asking pointedly about the strengths and weaknesses of the proposal. If the donor sees that the NARS is serious, a frank dialogue should result, and the NARS proposal writers can thus learn how to improve subsequent submissions. In international consulting companies, where the livelihood of all staff depends on having "winning" proposals, a group will feel it is doing an outstanding job if it wins one out of three contracts. If professional proposal writers experience this level of rejection, surely a NARS should accept that some fund-raising efforts will inevitably be wasted, at least in the short run. In the longer run, old

proposals need never die. They can be revisited, dusted off, and reworked into new, more attractive proposals to new donors.

- **Keep many irons in the fire.** Since proposal writers can expect that at least some proposals will be turned down, it makes sense to submit several. The more proposals submitted, the better the chances of getting one supported. (There is also the issue of whether to present the same proposal to more than one donor. Box 4 presents some thoughts on this.) If the NARS leader encourages all researchers to prepare research proposals, there should soon be enough irons in the fire to ensure that one gets hot every year!

Box 4. Submitting the Same Proposal to Multiple Donors

The same proposal can be submitted to several donors if the following conditions are met:

- It is explicitly stated in the cover letter that this is being done.
- The project budget is so large that no single donor is likely to provide the full amount. In this case, it may be prudent for the project designers to divide the project into several fundable pieces, one for each donor.
- The NARS leader is willing to take the risk that each donor will have fewer qualms about turning down the proposal, on the assumption that some other donor will probably say yes.
- The NARS leader is prepared to handle the complexity of receiving funds from multiple sources—different currencies, different rules, etc.

- **Accept the fact that fund-raising is a never-ending job.** NARS should by all means celebrate when the donor signals acceptance of a proposal. Then they should get on with preparing the next proposal. Fund-raising by nonprofit organizations like NARS is similar to the selling work done by profit-making entities. If there are no buyers for their products or services, they go out of business. Unless or until the NARS are privatized, and clients pay for scientists to undertake the research they want, NARS leaders will be seeking funds from their own treasury or from external donors. This means that designing projects and programs, preparing budgets, and "selling" ideas is an integral, on-going part of the NARS leader's job.
- **Cultivate patience.** Project development is a slow, sometimes agonizingly slow, process. Many stages are quite outside the proposal writer's control. Since NARS leaders cannot speed up these stages, they either learn patience or develop ulcers. They must decide which they prefer.
- **Remember the positive side of fund-raising.** The good news is that project development and fund-raising are never boring. Each proposal, each donor, each negotiation is different. A NARS leader will gain experience with each project, but the next one will still have the power to sur-

prise. So although fund-raising is for ever, it is for ever something from which everyone can learn!

Concluding Remarks

Mobilizing donor funds can be an intensely challenging but attractive way to expand the breadth and depth of work by a NARS. Proposals submitted for outside funding have a much better chance of being approved if they manage to integrate the research organization's objectives and concerns with those of the donor. This means that NARS leaders and scientists must understand where each donor is coming from, exploit that knowledge in the project design and proposal writing, and maintain a good rapport with the donor throughout project implementation.

On the surface, this may appear straightforward since, in two major respects, donors to agricultural research are pretty well all alike. They all have money to spend and they all want to support clearly targeted, executable research projects that will contribute to a partner country's economic and social development. In other important respects, however, donors differ markedly from each other. It is one of the jobs of the NARS leader to understand a donor's particular interests, motives, constraints, likes, and dislikes in order to get the most out of the relationship.

Some "donors," like the World Bank, are really lenders, while others provide outright grants. Some operate only in certain regions, countries, or subject areas, while others have a mandate for the entire developing world and fund projects on a wide range of topics. Many donors are bilateral agencies strongly influenced by the foreign policies of the national governments that fund them; others are multilaterals with broader subject focus and a more international approach to doing business. Some donors have tight strings attached to their funding, while others take a more hands-off approach. The key to successful mobilization of external funds is to be able to satisfy both the programmatic and bureaucratic requirements of these very different types of donors. In this respect, the chances of getting the green light for a proposal increase when the project design and proposal writing follow a rigorous, transparent, donor-sensitive process.

This puts the onus on research leaders and scientists to be entrepreneurial and develop skills other than those that have brought them success in the laboratory. These are the skills of the fund-raiser—among them, negotiation, public relations, writing for a nonspecialist audience, and budgeting.

Mobilizing donor funds is not necessarily quick or easy. Besides technical skills, perseverance and patience are needed while proposals are being developed and during the sometimes long waiting period of review and approval by host government ministries and donors. While the process may be onerous from beginning to end, working with donors can be a rewarding experience for the NARS. Not only does it bring in extra resources for research, it can also stimulate scientists to design much better research projects, ultimately leading to a better quality of life for farmers and other beneficiaries.

Reference

Horton, D. et al. 1993. *Monitoring and Evaluating Agricultural Research: A Sourcebook*. Wallingford, UK: CAB International.

Recommended Reading

Evered, D. and M. O'Conner. 1987. *Communicating Science to the Public*. New York: John Wiley and Sons.

This collection of essays, presented at a CIBA Foundation conference, describes, among other things, the public perception of science. The essays stress the need for credibility and state that every effort should be made to communicate science as effectively as possible. For scientists taking on fund-raising activities, the book, though somewhat dated now, may provide interesting insights into how the public sees their work, and thus how they should write and talk about it.

Gooch, M. 1987. *Writing Winning Proposals*. Washington, DC: Council for Advancement and Support of Education.

The author takes the reader systematically through the different steps in proposal writing. She also adds a few ideas on how to develop a "project office" infrastructure that will help to produce a steady stream of proposals. A bibliography with further references on the topic is included at the back of the book.

Daniels, D. and T. Dottridge. 1993. Managing Agricultural Research: Views from a Funding Agency. *Public Administration and Development* 13:205-215.

This fairly recent and short text looks at the challenges of agricultural research management and the project experiences of Canada's International Development Research Centre. It reflects on the broader needs and responsibilities of research management and outlines key areas for future donor support.

Howe, F. 1991. *The Board Member's Guide to Fund-Raising: What Every Trustee Needs to Know about Raising Money*. San Francisco: Jossey-Bass Publishers.

The book highlights the need for board understanding and responsibility in fund-raising. Key elements of a successful fund-raising program are featured, such as techniques and procedures in seeking funds, capital campaigns, prospect cultivation and proposal writing, ethics, and cause-related marketing. The book describes how management and board members can be effective in fulfilling this aspect of their role.

O'Connel, B. 1987. Fund-Raising. Nonprofit Management Series, No. 7. Washington, DC: Independent Sector.

Written especially for staff and board members of nonprofit organizations, this paper offers a solid introduction to the variety of fund-raising activities that any nonprofit group should consider.

Muturi, S. N. 1989. Rationalizing Donor Support of NARS (a NARS perspective). In *The Changing Dynamics of Global Agriculture: A Seminar/Workshop on Research Policy Implications for National Agricultural Research Systems, Feldafing, Germany, 22-28 September 1988*. Eds. E.Q. Javier and U. Renborg. The Hague: ISNAR.

Schurig, T. 1989. Rationalizing Donor Support for NARS. In: *The Changing Dynamics of Global Agriculture: A Seminar/Workshop on Research Policy Implications for National Agricultural Research Systems, Feldafing, Germany, 22-28 September 1988*. Eds. E.Q. Javier and U. Renborg. The Hague: ISNAR.

These two papers indicate how donor relations with agricultural research systems can be optimized. They provide a NARS perspective and a donor perspective firsthand. The contrast between the perspectives adds value to each of the papers, providing insights into donor motives and NARS concerns.

Annex 1. Writing a Winning Proposal: A 10-Step Model

Some general principles should be kept in mind when writing a project proposal:

- The purpose of a research activity is to solve a problem or achieve a desirable output. This purpose contributes to a larger goal of importance to human development.
- To solve the problem or achieve the output, a number of inputs need to be properly combined. This combination will include activities by individuals or groups: thinking, experimenting, observing, reading, analyzing, synthesizing, inferring, building, testing, concluding, and so on.
- The activities need to be carefully managed to ensure the outcomes are achieved efficiently, effectively, within budget, and within given time limits.
- The costs of the inputs and activities can be estimated in advance.

The following outline has been useful for many proposals:

Summary	What is this proposal all about?
Background	Why should this project be implemented?
Objectives	What does it seek to achieve?
Activities	What will happen during the project?
Outputs	What will result from the project?
Work plan	How will the outputs be achieved?
Evaluation	How will the project ensure that the objectives have been achieved? What else might be learned from the project?
Budget	What will the project cost?

It is not a good idea to actually write the proposal in the order presented above. Rather, it is recommended that the design team prepare its proposal in the following order:

Step 1: Objectives. These are the key to the whole project, so it is important not to rush this step. Once the objectives have been drafted, the team should ask itself: Are the objectives valuable? To whom? Are they clear, measurable, and realistic in terms of the anticipated inputs? The design team is strongly advised to consult with others when preparing the objectives. Members should take enough time to think them through clearly and get the wording right. It is important that a project not promise more than can realistically be achieved.

Step 2: Activities. Writing these up is easy for most project designers. Using the verb "will," they should explain simply and clearly what the research team plans to do. This section should include a description of the research methods to be used. Proposal writers should remember that many donor readers are not scientists; they should therefore present the scientific design as simply as possible. The activities section should also be as brief as possible. It should not include any discussion of why the project is important, or why the

NARS should be doing it. Such material belongs in the background section (step 5).

Step 3: Work plan. This is one of the most difficult sections to prepare and will probably need several revisions. The work plan should include details on all intended inputs and how they will be combined to achieve the project outputs. It should include sections on most or all of the following:

- inputs and level of effort: staff and consultants (in person-years, months, weeks or days); collaborators and partners (also in person-time); training (how much, for whom, where, and when); equipment (cars, computers, office space, etc.);
- administrative arrangements: specific roles of the NARS, national or international collaborators, other government agencies, donors, and farmer groups or farm families;
- time plans: use of graphs, charts, and a brief narrative to explain when activities will take place;
- purchasing plans: details of what will be bought when;
- training plan;
- schedule of workshops and seminars;
- reporting: specifics on how often the project will report to the donor.

Step 4: Budget. Governments and donors usually have their own preferred budget formats. Proposals can succeed using a variety of formats, but a NARS leader should use a single one for all proposals submitted by the institute. A good way to ensure that all involved are aware of the approved format is to prepare budget guidelines. In preparing a budget, project designers should not ask for more than they need. But they should also avoid underbudgeting since no one will be happy if a project fails because it lacked the necessary funds to achieve its objectives. The most important part of budgeting is to footnote each line item carefully with accurate and current unit costs. Donors want to see budgets that are inclusive, accurate, and transparent. In a multiyear project budget, designers should include lines for contingency and inflation, and break the budget into annual expenses, since it is unlikely that funds will be expended evenly throughout the life of the project. Some donors may also want the project budget to distinguish between foreign and local currency requirements.

Step 5: Background. Saying why the research should be done is an easy step for most researchers. It should include: (a) the context in which the project will take place; (b) the problem to be researched and the need for the solution; (c) previous research on the subject by the NARS and others around the world; (d) the comparative advantage of the NARS in undertaking the project; and (e) who will benefit from the results. This section should be short, crisp, and highly readable. It should not be scholarly and full of footnotes, since it is not a research report. It is advisable to use headings to break up the material, and the whole section shouldn't be longer than two or three pages. If more needs to be written to explain the background properly, it should be put in an annex.

Step 6: Outputs. This section should carefully identify the beneficiaries of the project's results. The purpose is to show who (farmers, researchers, women, research institutions, farmer organizations, NGOs) or what (sector, region, economy, country) will be better off, and how. The outputs should be as quantifiable as possible. How many people will be helped? By how much will production increase? How many more people will be trained to provide extension in a given technique? The more details provided, and the larger the number of favorable outcomes and impacts, the greater will be the donor interest in investing in the project. It may help to regard this section as the donor's "payoff"—the ultimate reason why the donor organization should invest its country's money in the proposed research.

Anticipated project results should be described in two ways: measurable outcomes and less tangible impacts. Separating this part of the proposal into two sections, headed "outputs" and "impact," will help to ensure that both are included. Donors are increasingly more interested in impact than outputs. From the donor's point of view, this makes good sense. A project may yield all the outputs it promised, such as a certain number of people trained, experiments undertaken, and new cereal varieties bred. But if the outputs have no impact, i.e., poor farm families aren't better off, food production doesn't go up, and rural incomes remain stagnant, the investments in the outputs will not have been worthwhile.

The impact of research outputs may be difficult to project since it is often beyond the control of the NARS. For example, much will depend on the behavior of extension agencies and NGOs and on prevailing government policies and economic conditions. To overcome this problem, the proposal should be clear about the conditions under which the predicted project impacts can be achieved. By specifying assumptions and provisos, the project designers can make their proposal more credible in the donor's eyes. The information may also be helpful to the planning division staff charged with prioritizing proposals. Overall, research proposals should try to persuade donor readers not only that the NARS can deliver the promised outputs, but also that, if others play their part, something important will be achieved.

Step 7: Monitoring and evaluation. This section describes how the project will test to see whether the planned outputs are being achieved. The most important thing about this step is to ensure that it is included! Many people forget to think about how they will monitor their project. However, few things give a donor more confidence that their money will be well managed than a well-conceived monitoring and evaluation plan. No donor will begrudge the money it takes to do this work well.

If the NARS already has an institutional monitoring and evaluation system in place, this should be described and assurances given that it will be rigorously applied to the proposed project. If the NARS doesn't have such a system in place, the design team will need to devise one for the project in question. The following issues need to be considered: First, should the project be monitored and evaluated in-house or should an outsider be engaged to give a frank and fresh appraisal from time to time. The in-house option will be cheaper, but perhaps not as useful. Second, will a baseline survey be needed? If so, this will be an early expense for the project. Third, how often will the project provide progress reports? Monitoring and evaluation data can be included in the annual or semiannual reports that will, in any case, be needed by the donor.

Step 8: Introduction and summary. This section summarizes what the proposed research is all about. Remember that although it is read first, it should be written last. The introduction/summary should be very short (maximum two pages, preferably less), clear, and highly readable as it may be the only section that some readers look at. All other sections of the proposal should be referred to here. The section should hold the reader's interest, but not be sensational.

Step 9: Reviewing and editing. This is one of the most important steps in proposal preparation. If possible, it should be undertaken after the project designers have had a chance to digest what they have drafted during steps 1 to 8. In re-reading the entire proposal with fresh eyes, they will catch any inconsistencies, omissions, or errors, and may very well have good ideas for improving the project design. This is also the point at which the proposal can be shortened and its readability improved.

Before the proposal is submitted to the donor, planning division, or ministry responsible for screening proposals, it needs to be reviewed again in-house. The review meeting should again be chaired by the NARS director, and scientists from all important divisions should be invited to attend and comment. This should be a formal event, taken as an opportunity for the best minds in the NARS to focus on each project being considered. Design teams should be prepared to do a final rewrite, taking into account the comments made by the review participants.

Step 10: Submitting the proposal. Whether the proposal is sent directly to a donor or forwarded to a planning division or ministry of external affairs, it should be accompanied by a covering letter. This can be drafted by the design team or prepared by the NARS director. In either case, time and care will be needed. Before writing a word, the author of the covering letter should think carefully about the person being addressed. What are his or her interests, fears, needs, and concerns? The covering letter should specify what the writer wants the reader to do and by when. Sentences like "My colleagues and I look forward to hearing that you have forwarded the proposal to . . . , when we telephone your office at the end of the month" may be useful. (If the proposal is being sent directly to the donor, the same principle applies.)

Chapter 11
Private Funding for Public Research

Carl E. Pray

Introduction

In the current climate of tight government budgets and increasing costs of research, scientists and administrators in public research institutes are seeking new sources of funding. This chapter attempts to give research managers, scientists, and policy makers some guidance on how to obtain money from the private sector.

A plan for a successful program of increased private-sector funding for government research institutes has four essential components. The plan must first assess which of the institute's research activities, technologies, and resources might interest the private sector. Second, it must assess the market for these activities. Which firms, groups of firms, or individuals would be interested in funding research or purchasing the technology, services, or assets? Third, the institute must decide on the institutional mechanism for linking the public and private sector. Finally, it must consider the costs and potential problems of obtaining private funding. These four components are used in Table 1 to analyze some of the major ways research institutions obtain money from the private sector.

The first row of Table 1 lists some of the main items for which money is obtained from the private sector. Research institutes can market the information and technology they produce. They can also use their land, machinery, and labor to produce and sell agricultural products. Some institutes have assets such as land, buildings, and factories that can be used to produce nonagricultural goods and services. For example, land and buildings can be rented out to retail stores, petrol firms, or factories. In some instances, land, office buildings, or entire laboratories may be sold. Finally, some institutes, particularly those integrated with universities, may be able to market their name and reputation to generate substantial funding, equipment, and sometimes land and buildings as donations and gifts.

Table 1. Ways Public Sector can Obtain Money from Private Sector

	Sell output of research	Sell agricultural products	Sell non-agricultural goods and services	Sell assets or research pro-grams	Gifts, donations
Demand	Agricultural input firms Agricultural processing firms Farms, groups of farmers, NGOs	Consumers Agricultural processing firms	Consumers Firms	Developers (land) R&D firms (labs and experiment stations)	Firms and people seeking PR or influence
Mechanism	Technology transfer office See Table 4	Institute sells Hire firm to sell	Own firm, joint venture Institute manages Hire firm to manage	Real estate office Auction by government Hire someone to auction	Foundation gift
Potential problems	See Table 4	Lose money Divert R&D resources	Lose money Divert R&D resources	Undervalue asset	Bad PR or influence

The importance of these sources of revenue varies widely across countries and across different types of research institutes within a country. Tables 2 and 3 show sources of revenue for a few institutes for which a fairly complete accounting of funding is available. Royalties and industry grants and contracts are important to State Agricultural Experiment Stations (SAES) in the USA, accounting for about 14 percent of revenue. They are much less important in the United States Department of Agriculture (USDA), INTA in Argentina, and INIA in Chile. The sale of agricultural products is an important source of funds for US SAES, INTA, INIA, and universities in Chile. The sale of nonagricultural products and services is important in only a few countries including China. Information from Chile (Venezian 1992) and the UK (Pray 1996) suggest that sales of land, laboratories, and offices are only occasionally important. Finally, gifts are an important source of funds, primarily at universities in the US (SAES are at universities). Venezian (1992) provides data showing that in Chile, too, gifts are very important for funding research and research equipment.

Table 2. Source of Funds for Public Agricultural Research in the USA, 1993 (millions of US dollars)

	USDA	Other federal	State	Agricultural products sales	Industry grants	Other (royalties, gifts)	Total
USDA agencies	1,076 97.0%	24 2.2%			(34[a])	9[b] 0.8%	1,109
All state agricultural experiment stations	400 19.7%	249 12.3%	985 48.6%	110 5.4%	148 7.3%	135 6.7%	2,027
New Jersey agricultural experiments station	4.3 18.8%	2.6 11.4%	11.7 51.0%	0.045 0.2%	0.396 1.7%	3.9 17.0%	22.9

[a]The total value of USDA and Industry Cooperative Research and Development Agreements. It is in parentheses because it is also counted in the USDA column.
[b]Patent license royalties account for $1.5 million.

Sources: USDA Inventory of Agricultural Research, Fiscal Year 1993. Washington, DC, 1994.

Table 3. Source of Funds for Public Agricultural Research in Argentina and Chile

Argentina (millions of US dollars), 1993					
	National government	**Agricultural products sales**	**Industry grants (joint ventures)**	**Royalties**	**Total**
INTA	111.2	7	1.6	0.2	120

Chile (% of total), 1990				
	National government	**Public competitive grants**	**Agricultural products sales**	**Industry, international, and other**
INIA	51.8[a]	2.0	38.9	7.3
University of Chile	49.4	17.7	28.0	4.4
Catholic University	22.5	22.6	3.9	51.0

[a]Includes IDB loan funds amounting to 20.9 percent of total.

Sources: For Argentina, Gutierrez, M. 1994. Experiencias en comercialización de tecnologías apropriables en institutos nacionales de investigación agropecuaria de América Latina. El caso del INTA de Argentina; and personal communication with INTA officials; for Chile, Venezian, E. L. Agricultural Research in a Growing Economy: The Case of Chile, 1970-90. Unpublished World Bank Report No. 10397-LAC, March 31, 1992.

The next section of this chapter concentrates on the markets, mechanisms, and potential problems of selling research output. It is the first and largest section because sale of output is the private-sector funding domain most compatible with the mandate and comparative advantage of most public research institutes. The third section describes in less depth the provision of the other goods, services, and assets listed across the top of Table 1. It follows the same structure: markets, mechanisms, and potential problems. The last section summarizes the findings from the first three.

Sale of Research Output: Information and Technology

Supply: What does research have to offer?

Agricultural research systems in developing countries have laboratories and experiment stations that conduct research on everything from the fat content of local beef to transgenic rice. The types of research at public agricultural research institutes, from most basic to most applied, are listed across the top of Table 4.

Examples of outputs from the various types of research are identified in the next line of the table. The output of basic research is knowledge, distributed primarily to other scientists through refereed academic journal articles. Basic research develops techniques that can be used by scientists conducting strategic and applied research; it rarely produces technology that can be commercialized. Very little basic research is done in agricultural research institutions. It is usually left to universities or institutes outside agriculture.

Strategic research also produces knowledge that is communicated to other scientists through journal articles. Some literature calls this type of research “generic” or “pre-technology” research. The main difference between basic research and strategic research is that the latter seeks answers to the practical problems of applied researchers or of people developing new products. It differs from applied research in that it doesn’t produce commercial technology.

Applied and adaptive research are the main kinds of research conducted by agricultural research institutes in LDCs. Applied research develops new technology and new management systems. Thus, it includes research by plant breeders, engineers, and agronomists. Adaptive research tests the technology developed by applied research or imported from other regions. Adaptive research includes trials of various technologies to identify which ones can be transferred to which region, e.g., pesticide efficacy trials and trials of different plant varieties and animal breeds.

Table 4. Earning Money from Research

	Basic research	Strategic research	Applied research	Adaptive research
Output	Knowledge about plants and animals Research techniques	Information techniques for use in applied R&D Materials & germplasm for applied R&D Techniques for industry	Management recommendations Plant varieties Machines Pesticides Fertilizers Plastics	Test varieties Pesticides Machines Fertilizers
Demand	Private food & agricultural input firms that do applied R&D Government agencies that do applied R&D	Private food & input firms that do R&D	Private input firms that distribute technology Groups of farmers Food industrx	R&D firms Farmers
Mechanism	Gifts by large firms	Research consortia with R&D firms Consulting to R&D firms Licensing research techniques	License technology Grants from groups of farmers Research contracts from farmers, input firms & processing Ownership of firms producing technology	Firms pay for tests Farmers pay for tests
Problems		Conflict of interest Conflicts over property rights Public good R&D resources Public perception Public funding Fluctuations of funding	Too much adaptive and applied R&D Public perception Public funding Fluctuations of funding	R&D resources not doing science

Demand: Who would want to fund research or buy technology?

Three types of groups have traditionally been interested in the results of public agricultural research: farmers, input supply firms, and processors of agricultural produce. Private firms fund research mainly because they believe it will increase their future profits. But they sometimes fund research or establish a private foundation for research because they believe such scientific activity will serve some important purpose in society. Most of this chapter works on the assumption that profits are the main motive.

The extent of the willingness and purchasing capacity of these groups, and the type of output desired depend in part on the size of the industry and its level of development. Large profitable firms can obviously pay more for research than smaller, less profitable ones. If the industry consists of small firms with primitive technology, it will be looking for research output such as new varieties. If it is a science-based industry, in which firms compete on the basis of the technology produced in their own labs, then the results of strategic and basic research will be the focus of demand.

The development of new industries and breakthroughs in science have opened up new potential customers for agricultural research. Recently in the USA and Europe, some firms that develop pharmaceuticals for human use, as well as those developing technology for toxic and nontoxic waste cleanup, have become interested in the results of public agricultural research.

The "Demand" line in Table 4 identifies types of firms interested in different categories of research. Input supply firms that have R&D programs to produce new technology for their own use are primarily interested in information and research techniques coming out of basic and strategic research. For example, conventional plant breeders in many seed companies use genetic screening techniques developed by public universities. In addition, research firms may be interested in contract research in LDCs whose scientists receive low salaries.

Private firms also encourage research that produces technology complementary to their own. Thus, chemical companies working on wheat herbicides may be interested in public research aimed at developing higher-yielding wheat varieties or varieties of other crops used in wheat rotations that are resistant to this herbicide.

Finally, seed companies, chemical companies, and machinery firms are interested in public-sector adaptive research that substantiates their claims about the virtues of their new products. They are also interested in research that shows how farmers can use their firm's technology most profitably or that provides an inexpensive way to test technology in new markets.

The food, textile, and beverage industries are big consumers of agricultural products. They are concerned about the quality and costs of their inputs from agriculture. For example, tobacco companies in LDCs are often willing to fund research that reduces the cost of leaf production or improves leaf quality.

Farmers want technology that reduces their cost of production or improves the demand for agricultural products. When the public research system cannot give these issues sufficient attention, farmers are often willing to tax themselves to finance such research either in the public or private sector. Farmers are more willing to do this if the crop is an export commodity, if their numbers are small and they are geographically concentrated, and if there are already well-organized farmer organizations in place (see Box 1).

Whether firms are willing to finance public research or buy its technology and services depends largely on the history and reputation of the research institute. If the institute is licensing technology it has already developed, then a prospective client firm has something solid to go on. It can do its own tests on the technology and check the results of field trials by other research institutes or extension agencies. However, if a firm is financing research or hiring a scientist as a consultant, it has to rely on the reputation of the individual and the re-

Box 1. Financing by Commodity Groups:
The Case of Rice Research in Uruguay

The introduction and development of new rice varieties in Uruguay was started by private farmers in the 1960s. In 1970 the Uruguayan government established an experiment station in the eastern part of the country with a mandate to improve rice production through varietal selection and research on seed quality, water management, and fertilization. The public and private rice research programs worked in parallel during the 1970s. In the early 1980s real public funding declined to the point where the government was able to provide salaries but not operating expenses for rice research. The private rice growers agreed to tax themselves to provide operational expenses for the government research program. A public agreement was set out for joint annual planning of research and extension activities.

This collaboration has been very successful in increasing rice yields through improved varieties and better agronomic practices. The social rate of return to public and private research expenditures from 1965 to 1985 was 52 percent (Echeverría et al 1989).

One reason it was possible to get farmers to fund public research was that there were only a few large rice farmers. "In 1987, 428 farmers produced rice on an average of 200 ha each" (Echeverría et al 1989, p. 5). Also some of these farmers were quite sophisticated technically, having their own research and extension programs.

search institute. If the research is strategic or basic, reputation will be based on scientific output such as books, journal articles, and prizes. If it is more applied, reputation will be based on past output of technology. If an institute has little or no technology or publications to its name, it is very unlikely that any firms will want to finance anything more than regional trials of their own technology.

Mechanisms: How do you make a deal?

The tradition among most public agricultural research organizations has been to hand over their new technology and information, free of charge, to government input producers, public extension services, and farmers. However, these institutes also have a wide range of options (the "Mechanisms" line in Table 4) for earning money from the private sector, based on the value of their expertise, information, and technology. These options include the formation of research consortia; technology licensing; marketing technology (directly by the institute or through joint ventures); commodity group funding; consulting by scientific staff; and contract research.

Research consortia. For strategic research, the most promising mechanism appears to be the research consortium. Under such an arrangement, a small number of firms, which usually have their own in-house research programs, finance strategic research at a public research institute or university on topics of common interest. The topics are chosen to increase the productivity of their applied research. The payments to the research institute may be large, in return for influence over research priorities and priority access to the knowledge created. Where technology is produced, consortium members usually are first in line to license the technology. Box 2 provides an example of a U.S. research consortium and an Indian organization that has borrowed its structure.

Licensing technology. When public research institutes conduct applied research that leads to a marketable new technology, they have two main options: license the technology or commercialize it. With licensing, the research institute provides technology only to those firms that agree to pay a royalty. An exclusive license means only one firm is permitted to use and sell the technology. In most cases, successful licensing depends on the existence of patent laws or laws on plant breeders rights. However, for a few types of technology— hybrid corn, for example—research institutes may be able to exclude those who do not pay the royalty even though there is no effective patent system in place.

Commercializing technology. A research institute may decide to commercialize a technology on its own, hold equity in a start-up firm created to commercialize the technology, or go into a joint venture with an existing firm. In countries where laws protecting intellectual property do not exist or where they do exist but are not enforced, it is not possible to patent and license inventions to an outside firm for royalties. Thus, the institute is forced to establish its

Box 2. Rutgers University Center for Advanced Food Technology (CAFT), USA, and the Applied Technology Centre, Processed Foods, India

In the early 1980s, the Food Science Department at Rutgers, the State university of New Jersey, USA, was one of the strongest in the country. A major program of the New Jersey Commission on Science and Technology (NJCST), which the State established in 1983, was to set up university-industry-State research centers. The Center for Advanced Food Technology (CAFT) was established in March 1984 with a $600,000 grant from the NJCST. Rossen and Solberg (1987, p. 100) note that its purpose is to conduct "basic interdisciplinary research on generic problems that, while nonproprietary, are of keen interest to the food industry at large; ... support Rutgers' quality of education and excellence in research; and ... [enhance] the economic strength of New Jersey's food industry."

Industry was initially involved in CAFT through an industry-university conference in October 1984. University scientists presented their ideas for research, and representatives of 30 firms critiqued them. Industry encouraged "researchers to collaborate in major research areas that truly needed a multidisciplinary approach" (Rossen and Solberg 1987). In 1985, five firms joined CAFT, and it began its research program with a project on water relations in food processing and storage. Once this project was successfully under way in mid-1986, CAFT sought new industrial members and launched a second research project on understanding extrusion cooking.

By 1991, CAFT's budget had grown to $6.5 million, of which 25 percent was paid by the State, 25 percent by 19 industry members, and 50 percent through federal government research grants. Industry members pay $40,000 per year and have to remain members for at least three years. Their contribution must come from the firm's research budget and not be a corporate grant. The corporation's research department, as the unit that must justify the expenditure as useful to the firm, is intimately involved in the CAFT program. Members may also make special grants to the university. For example, Nabisco provided $1 million toward a new building for CAFT.

continued on next page

continued from previous page

The benefits to industry members include access to leading scientists in academia who do basic research on food issues, to the center's scientific instrumentation, and to a pilot plant to test new products. Members can also license any patents developed at CAFT on a nonexclusive basis, but CAFT retains ownership of the patents.

A major benefit to the university is the increased funding for generic research, which is the type of research universities do best. In addition, information and ideas from industry are more readily available to Rutgers faculty because of their regular meetings with industry scientists. Research productivity has also been stimulated since basic and applied scientists from different departments at Rutgers are encouraged to work in interdisciplinary teams on common research problems.

In India in 1988, the Government of Karnataka, with some financial and technical assistance from USAID, established a nonprofit organization in Bangalore called the Centre for Technology Development. The center has many of the same functions as the New Jersey Commission on Science and Technology in promoting R&D and the development of high-tech industries. It is setting up three Applied Technology Centres (ATCs): for manufacturing engineering, for processed foods, and for tree crops. The ATC-Processed Foods was established in 1993 and is modeled on CAFT. Several members of the CAFT administration and faculty have visited it to provide advice.

It is too soon to tell whether the consortium idea can be successfully transplanted to India. The ATC-Processed Foods is just getting its research facilities and offices ready on the campus of the Indian Institute of Science in Bangalore. It has a building but little equipment and few scientists; and, so far, it does not have any industry members. Unlike CAFT, the ATC does not have a strong food science program to sell to industry. However, it can boast the involvement of the world-famous science and engineering faculty of the Indian Institute of Science. Thus, it should be an attractive partner for industry in the near future.

own production facility or set up a joint venture in which it has some control over production. In these instances, protection of intellectual property comes through secrecy and contracts. In China, for example, research institutions and universities have found it impossible to make money from licensing plant varieties or new chemicals since the state-owned seed companies and cooperative chemical companies refused to pay royalties beyond the first year or two. They are therefore establishing their own seed and chemical companies so that they can charge prices high enough to cover some of the research costs. In some cases Chinese institutes have come to realize that they have more opportunities to earn money abroad where intellectual property rights are stronger (see Box 3).

In countries where intellectual property rights are strong but private firms don't recognize the potential of new technology, research institutes or inventors may have to set up their own firms to commercialize technology. In American research universities, start-up companies may not have sufficient money to pay for the license to use a technology owned by the university. If the university believes the technology is commercially promising but it can't find anyone to pay royalties, then it may take equity in a new start-up company. The

Box 3. Chinese joint ventures with foreign firms

The Chinese government and agricultural research institutes have struck several deals with foreign companies on hybrid rice. The first ones were negotiated in 1981 by the central government with two multinational seed companies. The firms were supposed to pay an entrance fee of $200,000 and then $50,000 annually in return for exclusive rights to sell Chinese hybrid rice technology in the rest of the world. The Hunan Hybrid Rice Research Center (HHRRC) also obtained a U.S. patent on the process of producing hybrid rice. The Chinese government's agreement with the two companies meant that China had to stop providing other national governments and the International Rice Research Institute (IRRI) with male sterile lines and restorer lines as well as seed management technology.

These agreements had several problems. First, the Chinese government did not earn as much money as it had expected. The seed companies paid the annual fees only for a couple of years. Second, none of the money went to the research groups that actually developed hybrid rice at HHRRC. Third, the arrangements caused a dispute whereby IRRI threatened to cut off Chinese access to IRRI germplasm since China was limiting IRRI's access to Chinese germplasm. Last, the seed companies were disappointed because they weren't able to produce successful commercial hybrids using Chinese material.

The Chinese government learned from this experience. It re-established IRRI's access to Chinese germplasm and HHRRC negotiated a joint venture directly with a small research-based start-up company in Texas, USA. The venture was approved by the Chinese Ministry of Agriculture in 1994. The Texan company is to pay $20,000 for research on 3-line hybrids and a $150,000 entrance fee for 2-line hybrids which will be spread in payments of $60,000 the first year and $45,000 the next two years. HHRRC is to receive royalties of 3 to 5 percent on sales of hybrids based on their lines. HHRRC scientists work in Texas, an arrangement that gives them experience in collaborating with U.S. scientists and gives the Texan company access to Chinese knowledge and experience with hybrid rice.

university can make money by waiting until the company begins to turn a profit, or it can sell some of its shares once the company starts to attract the attention of private investors.

Funding from commodity groups. Much of the applied agricultural research conducted by public institutes generates information or technology unauthorized use of which cannot be prevented. Crop and livestock management research, for example, produces recommendations that can be passed on from user to user at little cost. Breeding self-pollinated crops is usually not very profitable and, thus, may also fall into this category. In these instances, institutes may be able to obtain funding from commodity groups or charge for related consulting and extension services. If specific producers or industries stands to benefit from such research, then farmer or farmer/industry associations may be willing to tax themselves to finance the work. The research could be conducted by in-house research institutes, by other private institutes, or by the public research institute. Associations of this type are funding research on export crops such as tea, coffee, sugarcane, rubber, and oil palm in many LDCs.

When an association is interested in funding outside research, it often sets priorities among general categories of problems (ones that its members would like research to work on) and then puts out a call for proposals. Once experts have rated the proposals for scientific merit, the association funds as many of the high-priority ones as it can. Where associations do not exist, the research institute may have to invest time and effort in getting some started.

Consulting. Many research institutes and universities that conduct strategic and applied research allow their scientists to take on consultancies for industry. This provides a way of transferring technology and ideas while discouraging researchers from leaving for higher-paying jobs in the private sector. Institutes often require a share of the consulting money to be returned to them to help finance overhead and other research costs. For example, at the Hunan Hybrid Rice Research Center in China, 30 percent of scientists' earnings from consultancies go back to the center. In India, the department of chemical technology at Bombay University receives one-third of faculty members' consulting fees (Bagla 1995). Universities in the UK, New Zealand, and elsewhere have their own consulting companies through which scientists' services are offered. The profits from these companies go back to the research institutes.

Contract research. Another way to earn money from strategic, applied, and adaptive research is through contract research. If private firms have specific problems they cannot solve through in-house research, they may contract with public institutes to do the necessary research. For example, a firm may need to test a new plant variety or chemical in regions where they do not have fields. In that case, it may contract a public research institute to do the work. This is one of the most common types of private funding of public research in LDCs. If the institute has scientists or laboratories well known in the field in question, they may be able to get contracts simply by notifying firms that they are available. A typical contract specifies the amount of money to be provided, the research expected (experiments rather than specific results), and ownership of any resulting technology or information.

Some research institutes that do basic and strategic research and whose programs are well known have been able to obtain funding from individual private firms for strategic research. As in the case of research consortia, these are firms that already have their own strategic and applied research capacity such that they are in a position to apply the results generated by public-sector institutes. Generally, these are multinational research firms and, in some countries, funding from them may be politically unacceptable. The International Institute of Cell Biology (IICB) in Kiev, Ukraine, provides an example of this type of funding and of some of the changes it implies (see Box 4).

Technology transfer office

It is important for research institutes to have a person or office specializing in private-sector relations. Scientists are often not the best people to market their technology and handle details of patenting and contracts, although it is essential that they participate in the process. As the volume of work grows, the number of specialized staff and offices will need to grow with it. In large U.S. research universities there are separate offices for research contracts with gov-

Box 4. Private Funding of Strategic Research: Ukraine's IICB

The International Institute of Cell Biology (IICB) in Kiev, Ukraine, conducts basic and strategic research on plants and has been at the cutting edge of biological research worldwide. It was established in 1989 by scientists from the Institute of Botany and the Institute of Plant Physiology of the Soviet Academy of Sciences.

IICB's founding scientists started developing their contacts with foreign firms in 1986 and 1987. Due to lack of foreign currency, researchers had been unable to purchase the enzymes, plastic wear, and other equipment necessary for their work. With a small amount of travel money from the parent academy, research leaders spent a month in the USA in 1987 looking for collaborators. First they tried small biotech companies, but after a week realized they would only get funding from large chemical and pharmaceutical companies. They were then able to develop several research contracts with larger companies. The first was with American Cyanamid in 1988.

For 1995, IICB's funding from foreign grants and contracts, amounted to about $450,000. This money has been used to pay for research expenses and to increase scientists' income. The contracts are with American Cyanamid, Schering of Germany, Nunhems Zaden of the Netherlands, and Phytotech in the U.S. IICB provides a variety of services including production and genetic transformation of plants; field trials of genetically transformed plants; plant breeding using advanced techniques; and collection and extraction of biological materials for pharmaceutical and agrochemical screening.

It was changes in political circumstances and funding that led to the shift in institutional structure in 1989, from departments in the Institute of Botany and the Institute of Plant Physiology to the creation of IICB. The new arrangements also forced IICB to conduct much more applied research. Several years ago a plant breeding program was started and systemic botanists were added to the staff enabling the institute to initiate its biological materials collection and extraction program. The overall number of scientists, though, has declined from 190 in 1987 to 140 in 1995.

ernment, patents and research contracts with private firms, gifts from firms and individuals, and real estate management. INTA in Argentina is one example of an institute that is making such arrangements as needed (see Box 5).

Choice of mechanisms

The type of institutional arrangements adopted by institutes to obtain private-sector funds will depend on several factors. First, the nature of the research is important, as indicated in Table 4. For example, licensing is a useful approach for generating income from applied research. Second, the characteristics of the private firms involved will have an influence on the type of mechanism used. Research consortia are the more likely kind of arrangement if there are a number of large firms that do their own applied research but need help with strategic or basic research. A third major factor is the institute's mandate and its clientele's expectations. If farmers have traditionally received free advice from public institutes and universities, they may not be willing to pay for it now. Or they may call for a reduction of their tax burden. Any decision of an institute to establish its own company to commercialize technology will be in-

Box 5. The Sale of Technology and Research Consortia, Argentina

In recent years, Argentina's National Agricultural Research Institute (INTA) has been innovative in its efforts to obtain private-sector funds in exchange for the technology it produces and the results of its strategic research. Its major source of funds other than government appropriations is agricultural product sales, that is, earnings from foundation seed, nursery plants, and other services provided from the farms it owns (see Table 3). (The foundation seed, from INTA varieties, bears a small royalty payment, 5 percent of sale price.) However, this source of funding has been threatened by private competition and there is the prospect of declines in public funding. INTA has therefore been prompted to look for new sources of funding.

In 1987, INTA established a technology transfer office. One of its aims was to increase income through joint ventures with private cooperatives and firms and through royalties on INTA technology. The office has four staff members and costs about $200,000 per year to run. The resources received from joint venture partners grew from nothing in 1987 to a peak of $1.6 million in 1993; royalty income (other than from foundation seed) rose to over $200,000 during the same period (Gutierrez 1994). The resources from partners are used mainly to cover the operational costs of applied research and salary increments for INTA scientists working on these research projects. One of the most successful joint ventures commercialized a livestock vaccine developed by INTA. Based on this success, the private firm was willing to finance more vaccine research at the institute.

More recently, Fundación ArgenINTA was established to "act as a facilitator for the relationship between INTA and the private sector, promoting the development of consortia and other arrangements for the funding of specific projects and activities" (Trigo 1995). INTA provides two staff members and offices for the foundation. The consortia provide funds for strategic research that will produce "disembodied technologies which cannot be protected but whose economic benefits can be appropriated by a limited number of well identified economic agents." The foundation has identified a number of INTA research projects that fit into this category, has written up the projects into investment proposals to present to industry, and has begun to find partners. For example, one consortium has started research to improve the quality of export fruit.

The technology transfer office has faced a number of problems. When it was first established, a plant breeders rights law was on the books but not enforced. Thus, it was difficult to earn royalties, and firms had little incentive to enter into joint ventures with INTA on plant research. A second problem has been the difficulty in getting public-sector scientists to accept some restrictions on their freedom to publish and talk about research that they have agreed to keep secret for a period of time. A third problem has been how to agree on an acceptable division of royalties and other private funds among scientists. Last, it takes a rather long time for the government to approve agreements.

fluenced by its ability to raise start-up capital and by public perceptions about what a public research institute should be doing and providing.

Potential problems

In pursuing private-sector funding, public-sector scientists and administrators need to be concerned with three overriding issues. First, will research productivity be undermined? Problems related to secrecy, conflicts over the distribution of money, and distorted research priorities certainly have the potential to do this. Second, will the amount of research conducted for public purposes be reduced? This could happen if public institutes do not bring in enough money to cover the cost of obtaining the private money, or if private funding ends up alienating supporters of public funding for research. Third, will there be any negative effects on income distribution in the country? Here the risk is that the pursuit of private funds could pull research away from work aimed at bringing benefits to the poor.

Secrecy and publishing. Scientific productivity in most agricultural fields depends on open scientific communication. If researchers are no longer allowed to discuss their work with colleagues because of secrecy agreements or because they are afraid of losing patent rights, research productivity may decline. In addition, most public institutions have the explicit mandate to disseminate research results widely, for the good of society, and in many countries scientists are rewarded on the basis of their research publications. There is indeed much pressure on scientists to publish—and to publish quickly, before their competitors do. This conflicts with the interest that private firms and university technology transfer offices have in patenting. Thus, agreements have to be worked out in advance about secrecy and scientists' rights to publish. If they are not spelled out in contracts, they can easily lead to expensive law suits and the abrupt end of research funding by private firms. Public institutions must carefully decide just how much secrecy they can allow. They must balance the benefits of private funding with the costs of reduced research productivity.

Finding ways to share the money. Royalties and private-sector funds can be used as an incentive for more research or they can destroy research teams and undermine public research productivity. Scientists in public research institutes in developing countries are often rewarded for length of service or political connections rather than research output. Therefore, monetary rewards for producing technology that farmers buy could provide a useful incentive to researchers. However, most technology is the result of teamwork. Producing a new plant variety, for example, requires not only plant breeders but also plant pathologists, entomologists, and other specialists. If only the breeder gets a financial reward, the rest of the team may stop working with the breeder and the production of new varieties may slip or even halt. Research institutes must find equitable ways of rewarding all major contributors to successful research.

When public universities in the USA receive royalties, they often subtract expenses for patenting, licensing, and marketing the invention and then divide the remaining money between the inventor, the inventor's academic department, and the university. The money for the department is intended to reward the patentee's colleagues and the share given to the university helps cover the cost of institutional resources used in the successful research.

Distortion of research priorities. Small amounts of private money can influence the direction of large amounts of public research. Many agricultural research institutes are in a situation where the government continues to fund scientists' salaries but has little or no money to cover operational expenses. For them, a small amount of operational funding can mean the difference between doing some research and doing nothing. Thus, money from the private sector has the potential to steer an institute away from a research agenda that might be the most productive for society as a whole.

If privately funded research, then, helps only a few input producers, processors, or farmers at the expense of many farmers, then its influence may be negative. The classic case is that of Canadian public research on barley financed by beer companies. The research emphasized the development of low-protein barley varieties that benefited beer producers but not farmers producing barley as fodder or cattle producers, who could have profited from cheaper high-protein barley (Ulrich, Furtan, Schmitz 1986). Conversely, private funding can have a positive influence on research productivity if it moves scientists away from projects that have little prospect of providing new technology to farmers. The long-term solution to the potential problem of priority distortion is not to stop private funding of public research but to ensure sufficient public money to do research that has important benefits to society.

Reductions in public funding. Public funding can be adversely affected, albeit indirectly, if the public loses confidence that the research institute is an unbiased source of information. If farmers or consumer groups who support public research institutes begin to believe that those same institutes are favoring agribusiness, they may lobby less for expenditures on public research. In addition, environmental and labor groups may criticize agricultural experiment stations, accusing them of supporting pollution and displacing labor. In some States in the USA, the legislature has reduced public funding for agricultural experiment stations in proportion to the royalties they earn.

Fluctuations in income from private sources. Several State Agricultural Experiment Stations in the USA have experienced dramatic fluctuations in revenue from private sources in recent years. The New Jersey Agricultural Experiment Station (NJAES) was making over $300,000 in royalties from asparagus varieties in 1989. It then got into a legal dispute with its exclusive licensee. Royalties declined to less than $8,000 in 1990, and NJAES also had to pay hundreds of thousands of dollars in legal fees. California wine producers provided the University of California at Davis $800,000 to $900,000 annually for research until 1991 when the amount was reduced to zero because of internal squabbling among producers. Private companies that finance research projects at universities often include clauses in their agreements that allow them to stop funding at any time, and companies often do so at short notice.

These examples suggest that research institutes need to be careful in making their arrangements for private funding. Contracts should be designed not to allow withdrawals of funds without advance notice. Also, institutes need a portfolio of projects from different sources of private funding and some flexibility in moving money around. Government institutional support and revenue from charging overheads are two ways to enhance flexibility.

Pricing research output and services. How much should public institutes charge for access to their research expertise and outputs via contracts, consortia, licensing, and so on? Scientists, especially those who have not worked in the private sector, usually overestimate the potential commercial value of their discovery and underestimate the costs (including their time) of bringing the technology to market. In trying to charge more than firms are willing to pay, researchers may end up with bruised egos or feel that private firms are trying to cheat them. A good technology transfer officer at a research institute will carefully and realistically estimate the commercial value of a research product and then demonstrate to government scientists why it is a realistic estimate. The officer will then attempt to capture as much of that value as possible, for example, by calling on a number of private firms to bid on the technology.

If an agreement with a public institute gives the private-sector financier the rights to the revenue generated by the research output, then the firm should cover the full costs of research. Among other things, this means paying for scientists' time, for a portion of the capital and equipment used, and for the administrative effort required to set up and execute the project. Otherwise, privately funded projects run the risk of eroding the research institute's resources.

Time requirements and financial returns. The pursuit of private funding can pull scientists and administrators away from research and away from their efforts to raise money from the public sector. Many days, weeks, or months of work may be devoted to convincing research consortia and farmers to finance research, or where such organizations don't exist, to setting them up. The production and marketing of goods and services also requires the involvement of research administrators and scientists. It is important to factor these expenditures of time into the total costs of any effort to earn money from private sources. Of course, not all money-making activities distract from research. For example, where private and public scientists work together in a consortium to establish research priorities and conduct research, public research may become more relevant to the needs of the market.

Research institutes should be aware that they may not make much money from technology licensing or other arrangements. Several recent papers have examined the revenue possibilities of technology transfer programs at US universities (agricultural and nonagricultural, public and private). Parker and Zilberman (1993) looked at the technology transfer programs of five universities of which one, the University of California, was a land grant university. They found that technology transfer programs sometimes bring in a large amount of money. The University of California's system, for example, has earned $18.6 million over the past 20 years. However, they are also expensive: it cost the University of California $6.8 million to run its patent office during the same period. The California system was unusually profitable. Parker and Zilberman (1993) quote a recent study which estimates that only 20 percent of US university offices of technology licensing actually make a profit, 50 percent break even, and 30 percent lose money.

Hidden financial costs. Protecting intellectual property is often an integral part of securing revenues from the private sector. Obtaining patents can be very expensive, but enforcing them may result in even larger, unexpected expenditures. An institute has to be ready to go to court to punish infringers; otherwise, its patent is nothing but a piece of paper. In Argentina, INTA and important private wheat breeders had to organize an association to take legal action against infringers of their plant breeders rights. In the USA, universities have had to spend hundreds of thousands of dollars defending their plant patents.

Tradeoffs. When it comes to earning capacity, there are trade-offs between different kinds of activities to consider. If research institutes have sold their land, for example, their ability to earn money through agricultural production is reduced. There are similar tradeoffs within research. If a public institute is developing new commercial plant varieties with a private firm, it may not be considered an impartial source of information for conducting yield trials on other new plant varieties. Thus, its earnings from yield trials might decline or its public funding might be reduced.

Income Other than from the Sale of Research Output

This section briefly considers each of the methods of obtaining money from the private sector listed in Table 1 but not covered in the previous section. The mechanisms used, the potential demand, and some of the problems that may be encountered are examined for each good, service, or asset.

Agricultural products

Sales of agricultural products are important to many research institutes, although it is often very hard to find this item in their published budgets. It can certainly be a profitable way to manage those lands that aren't currently being used for experiments. Table 3 shows that this is an important source of income in Chile but less so in Argentina. The products supplied are whatever the markets demand and are consistent with the research farms' resources (management, land, labor, and equipment).

There are two basic ways to produce and market the goods. The institute can allow nearby farmers to use the land in exchange for a share of the harvest (or rent money). Or, it can itself manage the land and market the produce with the help of institute employees. Leasing requires less time and institutional resources; but there is always the risk of contractors letting the quality of the land decline and of rents being difficult to collect. In some countries, India for example, leasing may lead to loss of land ownership. Management by the institute has the advantage of better control, but it can also use up valuable research resources.

One problem with earning money from agricultural production is that it pulls human and physical resources away from research in return for small amounts of money. The resources consumed are not only the field labor and land involved in the actual production, but also the time spent by institute administrators and managers on making decisions about production, marketing, and labor. There is an issue of efficiency here. Scientists and research administrators are usually not the best business people. Their contribution to society is likely to be greater when they do science than when they engage in farming. If one part of the research institute is simply a government-run commercial farm, then the country might be better off if the research institute sold the farm to more efficient private farmers and invested the money as a research endowment.

A second problem is that private farmers may consider the research institute's production operations to be unfair competition. Some of the research farm's costs may be covered by government funding, which might allow the institute to charge lower prices than competitors. This can alienate the farmers who should be providing political support for public spending on research. In the US, and perhaps other countries, the tax-exempt status of public research organizations may be threatened if they earn too much money from production.

Nonagricultural goods and services

Anecdotal evidence suggests that the production of nonagricultural goods and services is most common in China. To make money, agricultural research institutes there sometimes produce medicines, sell petroleum and spare parts for autos, or build and lease commercial real estate. These activities are due to several factors: the absence of intellectual property rights to protect technology produced by research institutes; low prices for agricultural products; and the rapid growth of the industrial and services sectors of the economy.

Opportunities exist when research institutes own land in favorable locations, have personnel with particular expertise, or have developed unique technology. However, institutes often need to enter into joint ventures or hire outside expertise to get into these new fields of activity.

The problems here are similar to those mentioned above: diversion of resources away from research in return for little money, alienation of the core clientele, and loss of nonprofit tax status. There is the additional problem of scientists and administrators being less knowledgeable about these sectors than they are about the agricultural sector. Thus, there is plenty of opportunity for mistakes while they are learning.

Sale of assets and institutes

As mentioned above, it may be better for an institute to sell land and laboratories than to manage them itself. For the period 1979-84, INIA-Chile raised 10 to 20 percent of its income from sales of property (Venezian 1992). Some of this land, previously on the outskirts of Santiago, was eventually engulfed by urban expansion, driving up its value. In Ecuador, the Inter-American Development Bank and World Bank are encouraging sale of commercial farms owned by the national research system, INIAP. The resulting money would be placed in an endowment to fund future research.

Selling an entire research institute is unusual. In a few instances, however, public agricultural research institutes have been sold to the private sector. A famous case was the sale of a section of the UK's Plant Breeding Institute (PBI) in 1987 (see Box 6). The initiative for privatization came from the national government, not the research institute which opposed the sale. It's worth noting that PBI was a highly successful institute, scientifically and commercially. For countries whose institutes have a less illustrious record, selling may not be so easy.

Box 6. Sale of Part of the Plant Breeding Institute, Cambridge, UK

The plant breeding section of the UK's Plant Breeding Institute (PBI) was sold to Unilever in 1987. PBI's experiment station was auctioned off together with the National Seed Development Organization (NSDO), a government-owned foundation seed company with exclusive rights to distribute PBI varieties. PBI's plant breeders were part of the deal. The sale was arranged by a merchant banker. A preliminary list of interested firms was narrowed down to a short list of three: Unilever, ICI, and Bookers. Unilever won with a bid of £66 million. Of this, £43 million went to the biotechnology part of PBI and the remaining £23 million went to Parliament.

The impact of this transaction on British agricultural research has probably been positive so far. The £43 million was used to build a new biotechnology laboratory at the John Innes Institute in Norwich and pay its research expenses for about 10 years. The new Unilever seed company invested in its own biotechnology laboratory and has increased research expenditures on plant breeding above the PBI level. British farmers continue to get a steady stream of new varieties. Both the newly privatized scientists and the public sector scientists seem pleased with the results (Pray 1996).

Several things make the PBI case unique and not easily copied by other countries. First, the combination of PBI and NSDO was profitable. This required an excellent breeding program and strong plant breeders rights to allow institutes to collect royalties from their inventions. Second, the timing was right. Unilever, one of the world's largest multinational corporations, wanted to expand into the international seed business at that time and to buy a world-renowned research institute to serve as the research base of that business. Third, much more of the money went back to scientists than the government originally intended. This had to do with PBI's official status as a charity rather than as a government-owned institute. Fourth, PBI was located on a very valuable plot of real estate just outside Cambridge.

Sales of land and institutes can be managed by government officials or by private companies—real estate firms for land and merchant bankers for research institutes. A major problem is the valuation of assets. Land values are often not easily established and given the weakness of some governments, this process provides an opportunity for fraud and corruption.

Another problem is that there may be considerable political opposition to the sale of government land or research institutes. There is a good possibility that the research institute's clients will lobby to prevent the sale, encouraged by scientists who don't wish to be privatized. Opponents of the sale may be further incited to action by the possibility of the assets being sold off cheaply to friends of the government.

A final problem is that there may not be attractive investment possibilities for any endowment fund created with the proceeds from the sale. If the only thing a government research institute is allowed to invest in is government bonds or government-owned banks, the endowment could soon be eaten up by inflation.

Gifts

Another potential source of resources for research programs is gifts, such as equipment, land, and money, from private corporations and individuals. These may be given directly or through foundations established by the corporations or individuals. The motives of gift givers vary. Some people and firms donate to universities and research institutes because they see them as making an important contribution to society. Others may be looking to increase their prestige or get a tax break. Private companies often want their gift to figure in their advertising.

In the USA, gifts have long been an important source of research resources for universities and agricultural experiment stations. In order to be exempt from corporate or individual income tax, the gifts must not be accompanied by any contract requiring the recipient to provide services or technology in return for the money. In 1993, gifts plus some other nongovernmental money amounted to some $134 million, or about 7%, of the research funds of all US SAES.

Only a few research institutes or universities in developing countries are taking advantage of this source of funds. In China, the College of Life Sciences at Beijing University received funds from a wealthy Hong Kong businessman who had made his fortune in the movie industry. The money was used to build and equip a major biotechnology laboratory. In India, several agricultural universities and research institutes have received money for research and seminars on hybrid rice from a foundation established by the founder of the Maharashtra Hybrid Seed Company.

Which individuals should be approached for gifts? If the research program is attached to a university or has university status, the alumni are important potential donors. Other individuals and groups worth contacting are former staff members who have moved to the private sector; agribusiness and the agricultural community, particularly well-educated people; professional societies of agricultural engineers, agronomists, and agricultural economists; farmer cooperatives and other farmer organizations; and lobby groups such as seed and pesticide industry associations.

A potential problem with gifts is that there may be substantial financial costs involved in accepting them. For example, Rutgers University was given a 158 ha farm on the condition that it be used for research on sustainable agriculture. To prepare the farm so it could be used for research, the university had to invest over $1 million. It therefore went to the New Jersey legislature for a special appropriation to meet the capital costs and some of the recurrent expenses of the farm.

Before accepting a gift, an institute or university also needs to examine carefully any strings attached, namely the payoff expected by the donor. If a private company wants to show off its contribution in its advertising, for example, will this embarrass the institution? Or if individuals want a building named after them, is a building available? In effect, a prospective recipient needs to decide whether the gift giver's conditions conflict with the mandate, image, or capacity of the institution?

Concluding Remarks

There are many ways of using the assets and outputs of public agricultural research to generate revenue from the private sector. To cash in on these possibilities, research institutes must have either productive research programs or valuable assets under their control. At the same time, there should be a sizable market of organized farmer groups or profitable agribusinesses willing to pay for research and technology. Laws to protect intellectual property, combined with effective enforcement of those laws, are also key ingredients for successfully earning money from research.

If done right, public research programs can sell their services and output through consortia, technology licensing, and research contracts without compromising their productivity. In fact, the injection of private money will often stimulate productivity. Where funding arrangements improve scientists' contact with their clients, research may also become more relevant since scientists are encouraged to focus on technology that farmers and other users say they are willing to buy.

Selling of research services and output to the private sector, however, is unlikely to bring in more than 10 or 20 percent of the research funding needed by most public agricultural research systems. In addition, there is always some risk that private funding will reduce rather than enhance productivity. This can happen if imposed secrecy over innovations stifles communication among researchers or if disputes arise within an institute over the distribution and expenditure of incoming money.

There are two other major risks to consider. First, private funding can sometimes distort research priorities, diverting the institute's attention away from efforts to serve the wider public good. Second, the amount of public research being conducted could decline if the institute has to consume public resources in the initial effort to capture private money. It could also decline if the attention given to private interests alienates supporters of public research, thereby resulting in cuts to public funding.

Sales of agricultural produce grown on research institute lands have been a major source of funding for a few research institutes, notably INIA in Chile. In some countries, though, the practice has been a bone of contention with farmers and private firms who see it as unfair competition. The risk here is that farmers, who should normally be among the primary defenders of public expenditures on research, may withdraw their support for the local research institute.

The sale of research assets such as buildings or land can also be an important source of revenue, especially in crucial periods when an injection of funds is badly needed. However, selling such assets obviously reduces the resources available for research and sometimes triggers stiff political opposition.

Finally, gifts of money, equipment, and land are a largely unexplored source of private funds in LDCs, but one that universities seem quite successful in exploiting. A key issue is whether there are strings attached, and if so, whether they constitute an acceptable "cost" in light of the recipient institution's public mandate and capacity.

References

Bagla, P. 1995. India Cracks Whip to End Addiction to State Funds. *Science* 267:1419-1420.

Echeverría, R. G., G. Ferreira, and M. Dabezies. 1989. Returns to Investments in the Generation and Transfer of Rice Technology in Uruguay. ISNAR Working Paper No. 30. The Hague: ISNAR.

Gutierrez, M. 1994. Experiencias en Comercialización de Tecnologías Apropriables en Institutos Nacionales de Investigación Agropecuaria de América Latina. El Caso del INTA de Argentina. Draft paper. Buenos Aires: INTA.

Parker, D. and D. Zilberman. 1993. University Technology Transfers: Impact on Local and U.S. Economies. *Contemporary Policy Issues* XI(2):87-99.

Pray, C. E. 1996. The Impact of Privatizing Agricultural Research in Great Britain: An Interim Report on PBI and ADAS. *Food Policy* 21(3):305-318.

Rossen, J. L. and M. Solberg. 1987. Rutgers University's Center for Advanced Food Technology. *Food Technology* December 1987:100-110.

Trigo, Eduardo. July 10, 1995. Pers. comm.

Ulrich, A., H. Furtan, and A. Schmitz. 1986. Public Returns from Joint Venture Research: An Example from Agriculture. *Quarterly Journal of Economics* 101(1):103-129.

Venezian, E. L. 1992. Agricultural Research in a Growing Economy: The Case of Chile 1970-90. Unpublished World Bank Report No. 10397-LAC, March 31, 1992.

Recommended Reading

Bagla, P. 1995. India Cracks Whip to End Addiction to State Funds. *Science* 267:1419-1420.

This brief article describes ways in which scientists at some of India's premier government research institutes and universities are trying to obtain funds from industry. Most of the examples are not from agriculture.

Center for Technology Development. November 1992. What It Is, What It Does, How It Works. Update. Bangalore: Center for Technology Development.

This is a brochure on the activities of the Center for Technology Development. The center is an attempt by the government of Mysore State in southern India to promote high-tech industries in the information, food (biotechnology), and other industries.

Gutierrez, M.B. Gestión de Tecnologías Apropriables en el Sector Agrícola: El Caso del INTA de Argentina. Presented at Curso Taller EMBRAPA, FAO, IICA, ISNAR sobre Organización, Estructura y Decentralización de la Investigación Agropecuaria, Brasilia, 9-13 March 1992. Buenos Aires: INTA.

This is a very useful example of what a national agricultural research institute in a developing country can do to speed the spread of technology and earn some money while doing so. It draws on the experience of INTA, the National Agricultural Research Institute of Argentina. INTA was very involved in the development and enforcement of plant breeders rights in order to protect its varieties.

Pray, C. E. 1996. The Impact of Privatizing Agricultural Research in Great Britain: An Interim Report on PBI and ADAS. *Food Policy* 21(3):305-318.

This paper describes the privatization of plant breeding in Great Britain. It looks at the impact on research expenditure, research output, and income distribution. Research expenditure on plant breeding seems to have increased, but total spending on applied research for plant agriculture declined.

Ulrich, A., H. Furtan, and A. Schmitz. 1986. Public Returns from Joint Venture Research: An Example from Agriculture. *Quarterly Journal of Economics* 101(1):103-129.

This is an example of how private interests can skew public research away from research that would have larger public benefits. In this case, the brewery industry was able to influence Canadian barley breeders, shifting them away from research on varieties that would reduce costs of animal feed to varieties that would reduce costs to the brewing industry. The authors show that this reduces total welfare in Canada.

Umali, D. L. 1992. Public and Private Sector Roles in Agricultural Research. Theory and Experience. World Bank Discussion Paper 176. Washington, DC: World Bank.

This is a useful review of the economic rationale for public intervention in agricultural technology production. It also contains a number of case studies of private research in developing countries. It indicates the complementary role of public and private research.

Venezian, E. L. 1992. Agricultural Research in a Growing Economy: The Case of Chile 1970-90. Unpublished World Bank Report No. 10397-LAC, March 31, 1992.

This a one of the few detailed studies of an agricultural research system in transition from government funding to a mixture of self-financing and government funding. It does not have all the details that a research manager or fund-raiser might like to have, but it does present numbers to indicate that such a transition can take place without destroying the public research institutes.

Chapter 12
Should I Seek Legal Protection for My Research Results?

Joel I. Cohen, Stephen Crespi, and Biswajit Dhar[1]

Introduction

Scientists, research directors, and policy makers in developing countries are facing complex questions and decisions about the protection of intellectual property rights (IPR) in agricultural research. If protection is to be introduced, which type will most directly address the perceived needs of research? What are the likely benefits of that protection versus those from leaving research results in the public domain? How can organizations ensure that their inventions become available for use?

This chapter reviews the application of IPR protection to agricultural research in developing countries and examines expectations that this will provide an alternative source of financing for research. It covers Plant Variety Rights (PVR), patents, material transfer agreements, and farmer rights.

Decisions about whether to adopt an IPR system hinge on several developments with which developing countries have to contend. New technology and germplasm are constantly entering and being used by the global agricultural research system. National research programs in developing countries require clarification on the rights and access to agricultural research innovations and genetic resources. The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs), and the Convention on Biological Diversity (CBD) are meant to provide such clarification. Nevertheless, countries that have undertaken commitments under both the TRIPs agreement and CBD need to define how to address the seemingly conflicting provisions regarding IPR of the two agreements.

[1]The authors wish to acknowledge the extensive contributions and review by Steven Price, Director of University-Industry Relations at the University of Wisconsin-Madison, John Barton of Stanford University, and John Komen of ISNAR.

Decision makers also want to improve their understanding of the processes of innovation in farming communities. In some countries, they are examining these alongside the innovations produced by scientists. For example, proposed legislation in India would extend IPR protection to farmers.

Last but not least there is the trend toward greater reliance on private-sector initiatives. This has far-reaching implications for agricultural research in developing countries, which has previously depended almost solely on government initiatives.

This chapter demonstrates that the use of IPR protection in agricultural research is a growing trend, offering a "defensive" strategy for public research. It cautions that there are difficulties in documenting any significant gains from using IPR protection as a strategy for generating new, external funds for research. The chapter underlines the fact that patents simply protect innovation and secure the potential rights for future development. The chance for national programs to earn financial benefits from research comes mainly from working with the private sector and by providing for technology transfer.

Intellectual Property Rights: The Invisible Membrane

Deciding among options for the protection and disclosure of innovations is a major challenge. Research managers must carefully consider which type of protection is appropriate for each innovation, whose needs are being served, and how to weigh expected costs and benefits. Their decisions must reconcile various factors: scientists' "perceived need" for IPR protection, institutional goals, the interests of the end users of the innovation, and national policy objectives. Mechanisms must be put in place to ensure the production and use of the innovation, especially opportunities for their commercial development and widespread application.

When IPR protection is adopted, it becomes an "invisible membrane" around scientific innovations and inventions (Figure 1). Following their incubation period in research laboratories, technologies pass through such membranes into the world of production and development, taking their place among other available options for meeting the needs and demands of farmers and consumers. Tailor-made for each innovation, the IPR membrane should provide a basis for clear and equitable relations between collaborating partners. It should help determine whether exemptions are necessary and what returns are to be expected for an innovation, whether it be produced by human capital or by biological capital within sovereign national boundaries.

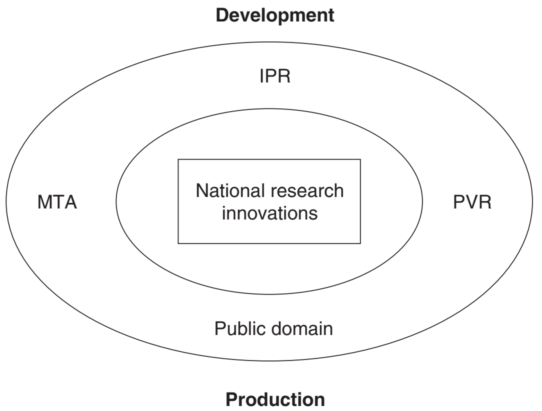


Figure 1. Adoption of intellectual property rights protection as an "invisible membrane"

Mechanisms for legally protecting agricultural innovations include: PVR and patents (extended to cover plants, animals, and microorganisms). These two systems are compared and contrasted in Table 1. Protection is also afforded through a third mechanism, material transfer agreements (MTAs), of a private contractual nature. Without some form of protection, research results are left in the public domain, most often in the form of publications. This presents a fourth option, namely making results available to all without restrictions on use.

Plant Variety Rights (PVR)[2]

Patent law was originally considered unsuitable for protecting new plant varieties developed by traditional breeding methods. Therefore, special national laws for PVR were introduced in the 1960s in some countries and by the International Union for the Protection of New Varieties of Plant (UPOV), established in 1961. These rights are granted by the state to plant breeders to exclude others from producing or commercializing material of a specific plant variety for a minimum of 15 to 20 years.

To be eligible for PVR, the variety must be novel, distinct from existing varieties, and uniform and stable in its essential characteristics. At first, this form of legal protection was limited to commercializing reproductive or vegetatively propagated material taken from a new variety. The variety rights granted to a breeder did not exclude use by farmers and researchers. Such exceptions under PVR systems are termed farmer's privilege and breeder's privilege (or research exemption).

[2]The term "Plant Variety Rights" and "Plant Breeders Rights" are synonymous. For purposes of clarity, here only the term "Plant Variety Rights" is used, since this corresponds most closely to the nature of the legal protection that is obtained.

Table 1. Comparison of Main Provisions of Plant Variety Rights under UPOV 1991 and Patent Law

Provisions	Plant Variety Rights under UPOV 1991	Patent law
Protection coverage	Plant varieties of all genera and species	Inventions
Requirements	Novelty, distinctness, uniformity, stability	Novelty, inventiveness, non-obviousness
Protection term	Minimum 20 years	17-20 years (OECD)
Protection scope	Commercial use of all material of the variety	Commercial use of protected matter
Breeder's exemption (research only)	Yes	Variable
Breeder's exemption (commercial use)	Yes, except for essentially derived varieties	No
Farmer's privilege	Up to national laws	Not yet
Prohibition of double protection	—	Not yet

Note: Revised from van Wijk et al., 1993.

Plant breeder rights under UPOV

The original 1961 version of UPOV was revised in 1972, 1978, and 1991. The 1991 version is not yet in force in most countries. Originally, the scope of PVR concerned "the production for purposes of commercial marketing, the offering for sale, the marketing, of the reproductive or vegetative propagating material, of the variety." UPOV 1978 also specified that any member state can provide patent protection or PVR protection, but not both, for the same botanical species or genus. This prohibition of double protection is not present in UPOV 1991. Researchers using biotechnology techniques alongside traditional breeding methods will be able to obtain both types of protection as appropriate. The status of PVRs in different countries is shown in Box 1.

Procedures and fees

The most important procedure in getting PVR is the examination of the biological material itself. Extensive field trials are necessary to determine whether the variety meets the legal requirements of distinctiveness, uniformity, and stability. The breeder must also supply an objective description of the new variety and list its characteristics in a qualitative or quantitative way so that it can be clearly distinguished from already known varieties. A variety is "novel" if it has not been commercialized before the date of the application for protec-

Box 1. Country Status of PVR under National and International Law

UPOV member States

Argentina, Australia, Austria, Belgium, Canada, Chile, Colombia, Czech Republic, Denmark, Finland, France, Germany, Hungary, Ireland, Israel, Italy, Japan, Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, South Africa, Spain, Sweden, Switzerland, Ukraine, United Kingdom, United States of America, Uruguay.

Applicants for UPOV membership

Belarus, Bolivia, Brazil, Ecuador, Mexico, Paraguay, Russian Federation.

Non-UPOV States having PVR national law

Estonia, Kazakstan, Kenya, Kyrgyzstan, Peru, Republic of Korea, Taiwan, Turkey, Uzbekistan, Venezuela, Zimbabwe.

States having advanced-stage proposals for PVR legislation

Bulgaria, China, Egypt, India, Malaysia, Moldova, Morocco, Pakistan, Romania, Tanzania, Thailand.

tion. Table 2 presents the fee structure for obtaining and maintaining PVR in the United Kingdom for 10 groups of crop species.

Each country must have a means of registering and certifying material selected for PVR. This is to guarantee that seed or planting material distributed to growers remains "true-to-type," that is, it retains the qualities originally stated on the application. To maintain confidence in the PVR system, there must be agreement among breeders and growers on the validity and utility of the system, with the benefits of compliance fully understood. The system must be

Table 2. UK Plant Variety Rights Fees (£) (Regulation 1994)

	Fees per test or application / annual renewal fees									
Species groups*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Application	245	245	245	245	245	245	45	245	120	245
Tests or examinations	665	410	620	580	495	410	75	165	210	165
Granting of PVR	130	130	130	130	130	130	35	130	105	130
Continued exercise of rights each year	390	390	390	390	390	390	45	295	155	295

**Species groups*: 1. Cereals (excluding maize); 2. Maize; 3. Potato; 4. Beetroot, brussel sprout, cabbage, celery, fenugreek, leek, turnip, carrot, curly kale, onion, radish, fodder crops; 5. Field pea, vegetable pea, field bean, broad bean; 6. Herbage, oil and fiber (including oilseed rape); 7. Rose; 8. Chrysanthemum; 9. Other decoratives; 10. Fruit.

able to ensure that a variety for which protection is sought meets the requirements of distinctiveness, uniformity, and stability. Apart from the financial constraints here, finding technically qualified personnel to staff a PVR office may present a major difficulty.

Patent Protection

To avoid legal confusion, patent law in many countries excludes plant varieties. For example, article 53b of the European Patent Convention excludes patents for "plant and animal varieties" and "essentially biological processes" for the production of plants and animals. Since the mid-1980s, a normal US "utility" patent can cover innovations in the production of new plant varieties or specific genes and their corresponding traits.

The process of obtaining patent protection depends heavily on an examination of the written word. In the case of microorganisms and other living matter, it is usually necessary to deposit a culture of a new organism in an official culture collection. The written specification contains the claims that define the protected technology. Claims almost always cover a range of products or processes extending beyond the specific application of the innovation by the inventor.

There has been a demonstrated rise in the use of patents in agricultural biotechnology. Since 1989, the rate has been about 250 patents per year (Joly and de Looze 1996). This is considered quite high given that such research is still an emerging field with great legal uncertainty. Some of the uncertainty is being clarified as companies involved in genetic engineering have recently consolidated their positions and are licensing or selling technologies. The increase in patenting is occurring in anticipation of technological breakthroughs, rather than from its proven economic importance to agricultural research (Joly and de Looze 1996).

Of most immediate interest to research scientists are patents covering genes and transformed plants that use those genes. This type of patent can cover a number of claims, such as isolated proteins, nucleic acid sequences coding for a protein, and plasmids containing that particular genetic sequence. The actual claim protects the patent holder against use of the gene by other scientists, but still leaves anyone else free to use and breed with organisms containing the gene as it occurs naturally (Barton, in press).

Another patent category protects basic processes and inventions. There are already many important patents covering transformation processes, plant growth promoters, and virus coat proteins which confer particular forms of resistance. The variety and scope of these are so broad that it is likely to be very difficult to develop transgenic plants without infringing one or another of these patents (Barton, in press).

Differences between patenting and PVR

PVR have been highly successful in their own sphere. However, the use of patent law is increasingly viewed as better suited for the protection of recombinant methods for producing transgenic plants and the resulting products (Suwantaradon 1995). PVR are highly specific to the variety and their scope is limited by reference to the physical (propagating) material itself, combined with the description of the variety given in the documentary grant of the rights.

The freedom to undertake research is safeguarded under both patent and PVR law (Table 1 and van Wijk et al. 1993). The freedom to commercialize the resulting products of research, however, depends on whether they infringe on patent claims or are "essentially derived" under PVR legislation. Neither system is a threat to the free use of existing germplasm since these rights can in no sense monopolize material known as such.

Decision making and procedures

Exercising judgment is more of a challenge when inventors are pursuing patent protection than when they are looking for variety protection. The legal and technical complexities, plus the time and money involved in navigating through the patent application process required for full international protection, are considerable.

As soon as the invention has been clearly described, it is time to consider filing a patent application. The first consideration is whether the gene, plant, process, or product is truly new (in patent law terms) rather than an obvious development of what is already known. It must have potential industrial or other utility. These criteria of patentability will be carefully applied by the patent office in its official examination of the application.

Decision making and patent procedures are discussed below and illustrated in Table 3. An application for patent protection is normally first made in the country of residence or place of business of the applicant, where this is possible. This establishes a priority date that will be recognized in most of the other countries of the world under the provisions of an international agreement known as the Paris Convention. In practice, this means that the major expense of a foreign patenting program can be postponed until one year after the initial filing date in the home country.

The value of this one-year interim period, both to industry and to other organizations that have to assess the potential industrial importance of new research results, is considerable. Moreover, under the Paris Convention the patent applicant can publish details of the invention at any time after the priority date without detriment to patent prospects. The only provisos here are that the invention be clearly defined and well-supported by data in the first application and that the foreign applications be filed no later than one year after the first application.

Table 3. The Patenting Process

Moment	Action by inventor	Action by patent office
Before first application	– Invention and preliminary appraisal of patentability	
First application	– First patent application filed in home country – Establishing priority date	
Within 12 months after first application	– Further development of invention and technical/commercial assessment by internal staff, consultants, industrial and government contacts – Decision taken to proceed or abandon, and costs estimated – Patenting route selected (national, European, international)	– Official prior art search (novelty search)
12 months after first application	– Home filing consolidated – Foreign applications filed based on priority application	– Official examination starts, precise moment depends on backlog
18 months after first application		– Official publication of application (in some countries)
At a later moment variable in time	– Further prosecution of patent application by applicant and attorney	– Patent granted or refused

Applicants who file priority applications in their home country normally use the ensuing year as a breathing space in which to consolidate their position. In most countries, the first filing will not be taken up immediately for full examination by the patent office and will remain secret until the formal publication stage is reached. This gives the applicant a limited period of effective trade secrecy in which various important matters can be further considered.

Technical development and assessment

Any further technical development of the invention during the year following the first filing can be made the subject of further patenting efforts. These can either stand alone or may be merged into a final overall application filed near the end of the first year. A final application thus contains the totality of the inventor's results over the periods preceding and following the first filing. It is usually the basis of the foreign patent applications, which can be filed abroad at this time and which claim one or more of the various priority dates given by the earlier national filings.

Commercial assessment and cost factors

Apart from the technical assessment, marketing and other commercial factors need to be considered before the end of the first year after filing. Whether to proceed and, if so, on what territorial scale are essentially decisions about market potential and the corresponding financial expenditure on patents that can be justified.

Filing the first application in one's home country protects the home market and establishes a base from which to secure wider coverage. Although costs begin to mount if international coverage is required, a large proportion of these can, fortunately, be distributed over time. At each stage of patenting, separate estimates of financial costs and benefits can be made in light of the prevailing commercial climate. A proper judgment about costs must take market size into account. For example, a cost of $15,000 or more to secure a US patent may not be considered excessive in relation to the potential US market.

These calculations or estimates of costs and benefits are far more difficult to make in developing countries than in industrialized countries since market opportunities are normally harder to identify. Scientists in national research programs and universities of LDCs also have far fewer opportunities to enter into commercial or strategic alliances that may help produce, market, or advertise a particular invention. Thus, the costs of filing at home and securing international protection may far outweigh the expected economic returns.

Patent costs arise at various stages over an extended period but can be terminated if the value of the protection diminishes over time. They consist of official fees charged by patent offices and professional fees charged by patent attorneys. Professional charges are based on standard fee scales and on the time spent. Time-based charges will vary from one patent application to another and according to professional rates in effect in the country of filing. Initial filing to set up a patent base may cost as little as $2,000; but it could also be 10 times that amount if the legal and technical complexities of the case are demanding. One year later, at the foreign filing stage, more expenditures will be incurred since the services of foreign agents will be needed and documents may have to be translated. Seeking protection in the major European countries, the USA, and Japan costs roughly $10,000 to $20,000.

The Patent Cooperation Treaty (covering international or "PCT" applications) covers a wide range of countries and offers a system of initial and deferred costs. In selecting countries in which to file for protection, it is important to distinguish between those in which the product will or could be manufactured and those that are simply markets. Various cost structures for patents are shown in Table 4, which summarizes initial filing fees under the European Patent Convention and the Patent Cooperation Treaty.

Table 4. Initial Filing Fees[1]

Type of fee	Fee in US dollars
European Patent Convention*	
Filing fee	420
Search fee	1,329
Designation fee (per country)	245
Examination fee	1,958
Grant fee (first 35 pages)	978
Patent Cooperation Treaty**	
Transmittal fee	Up to 100
Basic fee	677***
Designation fee, per country or regional patent	164***
Search fee	500-1,700
Examination fee (handing fee plus exam fee)	1,000-2,500***

* EPC, May 1995; ** PCT, 1 January 1996; *** A 75 percent reduction in the basic fee, the designation and confirmation fees, and the handling fee is available to applicants from most developing countries.

[1]These are illustrative figures. Actual fees vary by country, examination provider, and filing location.

Other Protective Mechanisms

Material transfer agreements

Contractual in nature, material transfer agreements (MTAs) offer a form of intellectual property protection that can cover material not generally protected by patents (Barton and Siebeck 1994). Such agreements are used by most international agricultural research centers for the genetic resources they hold in trust for the world community. They are also widely used among public-sector research organizations in industrialized countries. MTAs provide interim protection for material sent to collaborating organizations for advanced research. They can thus be used until such time as more formal IPR is sought.

MTAs are becoming especially important in the exchange and use of plant genetic resources, particularly since open access to such material is essential for the development of food and agriculture. In effect, MTAs can help clear the way for research and breeding by setting out the conditions that govern each germplasm exchange.

Farmers' rights

Although not formally a part of the Biodiversity Convention, farmers' rights were seen as a related concept in public debate. First formulated in Resolution 5/89 of the 1989 FAO conference, "'farmers' rights' means rights arising from the past, present and future contributions of farmers in conserving, improving, and making available plant genetic resources, particularly those in the centers of origin/diversity..." (FAO 1989). (Farmers' rights should not be confused with the so-called farmer's privilege mentioned above.)

The original intent of farmers' rights was to provide recognition to farmers and members of indigenous rural or traditional communities for their role in creating, domesticating, and building sources of agricultural varieties and diversity for food and agriculture. However, it is not clear how farmers' rights are to be given practical legal expression. It may prove difficult to graft this kind of right to traditional intellectual property law, in which case it will almost certainly be necessary to create a specialized new legal framework. With developing countries in mind, article 27(3) of the GATT (TRIPs) agreement of April 1994 envisaged special types of legal systems for plant and animal varieties, although these have not yet been defined or detailed.

The Continuing Debate on IPR

Agricultural development, including the release of improved planting materials through formal breeding and production, has benefited from a long history of public-sector/public-good investment. At the core of this system has been the wide availability of plant genetic resources.

But such public-good investments face an uncertain future. First, an increased emphasis on market mechanisms has forced publicly funded organizations to respond to broader economic and market opportunities and to position themselves to be part of the future global agricultural research system. Second, there is a tendency to restrict the free availability of germplasm to breeders working in publicly funded national agricultural research programs.

While many of those representing the formal and informal sectors oppose the use of patents on agricultural improvements, public institutions are increasingly being encouraged to protect their intellectual property (Baenziger et al. 1993). It is not a universal phenomenon, though. Many developing countries, India being one example, are being cautious about extending intellectual property protection to agricultural crops (Rai 1994). Current thinking in India on the country's IPR framework attempts to take into account the interests of those using planting material. The preference is to continue to leave research results in the public domain.

These problems and issues arise as IPR generally, and patents in particular, are adapted to cover living organisms, genes, and biological processes related to agriculture. But even early on, many countries judged patent systems to be inappropriate for protecting living things because of the practical restrictions they imposed (ODI 1993). The increased use of IPR protection in agricultural research does not seem to account fully either for the long-standing tradition of public-sector investment or for the innovations contributed by international agricultural research and by informal or indigenous communities. It is feared that such protection destroys the public-good nature of agriculture, especially as it relates to the needs of the rural poor. Material transfer agreements (if carefully prepared to ensure agreed-on use) and research exemptions could allay fears regarding access to material protected by patents.

Exemptions to Intellectual Property Rights

UPOV has until recently provided exceptions to breeders' rights to allow protected material to be used by farmers and by breeders (in the latter case, only for research purposes). The former exception, known as farmer's privilege, was provided in article 5 of UPOV 1978. According to this article, the rights of the breeder in the case of a protected plant variety were (a) production for purposes of commercial marketing, (b) offering for sale, and (c) marketing. This provision specified that the breeder's authorization was required to undertake production for commercial purposes. This was interpreted as meaning that no authorization was necessary to use the seeds on farms where the variety was grown. Thus, farmers could use the propagating material from the previous year's harvest.

PVR exemptions allowing farmer's privilege are especially important to those producers who don't rely on purchased inputs but tend to save their own seed and exchange some of it among themselves each year. In India, any attempts to weaken farmer's privilege and therefore rural communities have led to strong protests by farmers (Dhar et al. 1995).

The exception for breeders, sometimes called "research exemption," was provided in UPOV 1978. It stated that the breeder's authorization would "not be required either for the utilization of the variety as an initial source of variation for the purpose of creating other varieties or for the marketing of such varieties."

The two exceptions to the breeder's rights have, however, been modified in the latest amendment to the UPOV convention (1991). Article 14(1) extends the breeder's rights to all acts pertaining to production and reproduction of seeds and other planting material. Thus, unlike the provisions of UPOV 1978, there is no longer an implicit right of farmers to save and reuse seed from protected varieties without the breeder's authorization.

Article 15(2) does, however, provide some leeway for farmers: "...each Contracting Party (to UPOV '91) may, within reasonable limits and subject to the safeguarding of the legitimate interests of the breeder, restrict the breeder's right in relation to any variety in order to permit farmers to use for propagating purposes, on their own holdings, the product of the harvest which they have obtained by planting, on their own holdings, the protected variety..." Here, "legitimate interests" refers to the royalties that should be paid to the breeder for reuse of seed. Thus, the new provisions allow farmers to reuse the protected material, but only if they pay. It is expected, that royalty rates for use of farm-saved seed will be lower than for purchased seed.

Another provision of UPOV 1991, article 14(5), strengthens the breeder's rights by extending protection to "essentially derived varieties and certain other varieties" of the protected varieties. However, the free availability of protected varieties as a source of germplasm for the introduction of further variation is reaffirmed by article 15(1). That provision says that the breeder's right shall not extend to "acts done for the purpose of breeding other varieties." The freedom of research is therefore safeguarded. The extension of the breeder's rights to cover essentially derived varieties is expected to be limited to those varieties that take over virtually the whole of the genome of the protected variety. In matters of dispute, this may therefore require scientific evidence before a legal tribunal (Greengrass 1996).

Costs and Benefits of IPR Protection: The Lack of Empirical Social and Economic Analysis

In evaluating options for IPR protection, we must recognize that virtually no empirical analyses, either sociological or economic, have been done on the impact of IPR on food and agriculture, especially in developing countries. In industrialized countries, there is a clear correlation between plant variety protection and the willingness of companies to produce varieties. Without strong protection, there would be few new varieties available for the public benefit (Price and Lamola 1994). In addition, when national legislation allows public institutions to retain property rights, the number of patents increases since these facilitate licensing agreements.

While the up-front costs of obtaining IPR protection and building national competence in this area of expertise are fairly clear, it is harder to predict what the benefits to developing countries would be. Where domestic research isn't internationally competitive or where IPR laws are ignored and protected material reproduced illegally, it is especially difficult to expect any substantial payoff.

A recent review has found that there is still insufficient evidence to generalize about the benefits of establishing property rights for plant material. However, it is clear that private incentives for research on crops and the amount of plant variety protection sought increases with the value of the crop (Butler 1996). Expected benefits from IPR protection would be very low for plants or farming systems depending on low-value or open-pollinated crops.

The traditional role and comparative advantage of national agricultural research systems in developing countries is in the production and dissemination of public goods. These systems are at a distinct disadvantage in starting up in-house facilities for advising on and handling the protection of intellectual property. The financial outlook for many national programs is that of declining research budgets and operating funds, compounded by increased staffing costs (see Chapters 15-17). The financial, organizational, and staffing resources needed to set up and run IPR protection systems would simply increase the strain on already overstretched operating budgets.

If a good portion of national research is targeted for international or global application, then such investments in IPR protection may be justified. But it is not appropriate to shift all national program research efforts toward products that can be patented or protected by IPR. In this regard, the introduction of

IPR protection to agriculture is often cited as a means to counter the decline in funding to national agricultural research. It is argued that IPR protection mobilizes additional money from the private sector (because it creates an expectation of return on investments) and that it gives scientists access to protected material (Smith 1996).

While an evaluation of the utility of a patent system for plants, including cost-benefit analysis, may be recommended, in practice this is very difficult to do. In addition, the international agreements mentioned above do not allow a lot of time for such analysis, nor do the needs of those wishing to protect innovations and seeking financing for their development within the developing countries themselves (Butler 1996).

Selecting Forms of Protection

So far, this chapter has given an overview of the various forms of IPR protection, as well as considerations of publication, exemptions, and costs/benefits. Selecting from among the several types of protection is a complex management decision. In many public organizations, offices of intellectual property have been set up to help with these decisions. One of their jobs is to consider the accountability requirements and public expectations regarding innovations produced with public funds. Such offices can also help the national research program to anticipate the need to scale up, develop, and move its innovations into production. These needs are summarized by the term "technology transfer." Especially when it refers to serving farmers who rely on purchased inputs and make capital expenditures, technology transfer will usually include the licensing of some proprietary right. Examples are patents, PVR, rights derived from secret know-how, and proprietary biological material (Crespi 1995).

In deciding on which forms of IPR protection to adopt, it is important to consider whether an innovation will have only national application or perhaps wider, even global, relevance. Applying innovations to the needs of farming communities not traditionally reliant on purchased inputs requires no IPR protection. In fact, the costs of such protection would far outweigh any commercial benefits. However, if that same innovation has global implications, then some form of protection may well be advised.

While research managers and directors consider these various forms of protection, each country as a whole is considering them as well. For example, in 1995 new guidelines endorsed by the Department of Biotechnology in India required almost every research application to involve a commercial partner and to concentrate in areas that can be patented (Mudur 1995). More recently, the Indian Council of Agricultural Research (ICAR) established an Intellectual Property Rights Cell; rules for consultancies, contract research, and training are being drafted.

Conclusions

The case for extending IPR protection to agriculture depends critically on the impact this is likely to have on the farmers who purchase planting materials and on those providing services to farmers. In most developing countries, small and medium-scale farmers and those operating in a resource-limited environment form the core of the agricultural system. Any system of IPR protection must take into account the needs of this community as well as the services provided to the commercial or highly productive sector.

In relating financing opportunities and decision-making to patents and other forms of legal protection, it should be noted that the application of IPR to agricultural products is a very recent phenomenon. There is little record of the overall utility or success of patenting innovations. Revenues gained from IPR protection may help pay the costs of maintaining the structures necessary for providing researchers with advice on IPR, documenting innovations, and preparing applications, but not necessarily much more.

What is most important is for national programs to ensure their scientists have options open to them. Then, when exceptionally important innovations are made, a suitable form of IPR protection can be given. However, if a country's national policy does not encourage or even permit IPR, a scientist's options are obviously limited. Such countries will be at a disadvantage in the arena of international technology transfer, leaving the use or abuse of their domestic scientific advancements to the discretion of other national or private R&D organizations.

References

Baenziger, S. P., R. A. Kleese, and R. F. Barnes (eds.). 1993. Intellectual Property Rights: Protection of Plant Materials. Executive Summary and Work Group Reports. CSSA Special Publication No. 21. Madison, USA: Crop Science Society of America.

Barton, J. H. In press. International Intellectual Property and Genetic Resource Issues Affecting Agricultural Biotechnology. CSSA Special Publication. Madison, USA: Crop Science Society of America.

Barton, J. H. and W. E. Siebeck. 1994. Material Transfer Agreements in Genetic Resources Exchange: The Case of the International Agricultural Research Centers. Issues in Genetic Resources No. 1. Rome: International Plant Genetic Resources Institute.

Butler, L. J. 1996. Plant Breeders' Rights in the U.S.: Update of a 1983 Study. In *Intellectual Property Rights and Agriculture in Developing Countries.* Eds. J van Wijk and W. Jaffe. Amsterdam: University of Amsterdam.

Crespi, R. Stephen. 1995. Intellectual Property in Agricultural Biotechnology: Issue for Developing Countries. In *Proceedings of a Regional Seminar on Planning Priorities and Policies for Agricultural Biotechnology in Southeast Asia.* Workshop in Singapore, 25-29 September 1994. The Hague / Singapore: Intermediary Biotechnology Service / Nanyang Technological University.

Dhar, B., B. Pandey, and S. Chaturvedi. 1995. Plant Variety Protection in India: The Prospects. Research and Information System for the Non-Aligned and Other Developing Countries.

FAO. 1989. Interpretation of the International Undertaking on Plant Genetic Resources, 89/24. Rome: Food and Agriculture Organization.

Greengrass, B. 1996. Pers. comm., letter, and report to Stephen Crespi.

Joly, P. B. and M. A. de Looze. 1996. An Analysis of Innovation Strategies and Industrial Differentiation through Patent Applications: The Case of Plant Biotechnology. *Research Policy* 25:1027-1046.

Mudur, G. 1995. New Rules Push Researchers Closer to Biotech Industry. *Science* 269:297-298.

ODI. 1993. Patenting Plants: The Implications for Developing Countries. ODI Briefing Paper, November 1993. London, UK: Overseas Development Institute.

Price, S. C. and L. M. Lamola. 1994. Decision Points for Transferring Plant Intellectual Property to the Private Sector. In R.P. Adams, J.S. Miller, E.M. Golenberg and J.E. Adams (eds). *Conservation of Plant Genes II: Utilization of Ancient and Modern DNA*. Monograph in *Systematic Botany* 48. Missouri Botanical Garden, St. Louis: Scientific Publications.

Rai, Mangla. 1994. The Current Situation of the Plant Breeding and Seed Industries in India: The Policy on the Protection of New Varieties. Seminar on the Nature of and Rationale for the Protection of Plant Varieties under the UPOV Convention, organized by UPOV, Beijing China.

Rzucidlo, E. C. and D. R. Auth. 1996. Will the Real Inventor Please Stand Up? *Nature Biotechnology* 14:358-359.

Smith, S. 1996. Farmers' Privilege, Breeders' Exemption and the Essentially Derived Varieties Concept: Status Report on Current Developments. In *Intellectual Property Rights and Agriculture in Developing Countries*. Eds. J. van Wijk and W. Jaffe. Amsterdam: University of Amsterdam.

Suwantaradon, K. 1995. A Private Company's Perspective on National Policies Affecting Biotechnology Research in Thailand. In *Turning Priorities into Feasible Programs. Proceedings of a Regional Seminar on Planning, Priorities and Policies for Agricultural Biotechnology in Southeast Asia*. The Hague / Singapore: Intermediary Biotechnology Service / Nanyang Technological University.

Van Wijk, J., J. I. Cohen, J. Komen. 1993. Intellectual Property Rights for Agricultural Biotechnology: Options and Implications for Developing Countries. ISNAR Research Report No. 3. The Hague: ISNAR.

Recommended Reading

Baenziger, S. P., R. A. Kleese, and R. F. Barnes (eds.). 1993. Intellectual Property Rights: Protection of Plant Materials. Executive Summary and Work Group Reports. CSSA Special Publication No. 21. Madison, USA: Crop Science Society of America.

This document reviews the position of PVR and patent rights. The document looks mainly at the USA. Since developments in PVR in that country have anticipated those in other parts of the world, the relevancy of the document for people from other regions is still very high.

Barton, J. H. and W. E. Siebeck. 1994. Material Transfer Agreements in Genetic Resources Exchange: The Case of the International Agricultural Research Centers. Issues in Genetic Resources No. 1. Rome: International Plant Genetic Resources Institute.

The authors explain the MTA construction in detail and how they may be used to govern germplasm management by the international agricultural research community. Special attention is given to the issue of sovereign rights over genetic resources in developing countries.

Siebeck, W. E. (ed.), R. E. Evenson, W. Lesser, and C. A. Primo Braga. 1990. Strengthening Protection of Intellectual Property in Developing Countries: A Survey of the Literature. World Bank Discussion Paper No. 112. Washington, DC: World Bank.

This discussion paper tries to assess to what extent developing countries will benefit from strengthening their IPR legislation. The authors have reviewed literature covering the economics of patents and other instruments of intellectual property. They conclude that in developed countries IPR legislation has proven to be a large enough incentive to offset the costs of restricting technology access. Similar conclusions cannot be drawn for developing countries because of the lack of data.

Van Wijk, J., J. I. Cohen, J. Komen. 1993. Intellectual Property Rights for Agricultural Biotechnology: Options and Implications for Developing Countries. Research Report No.3. The Hague: ISNAR.

The authors discuss the increasing significance of IPR for agricultural biotechnology, the international debate on IPR, and possible developing-country strategies in the field of intellectual property rights. An analysis is provided of the complexities, options, and implications regarding IPR in relation to three national technology objectives: acquiring public or proprietary biotechnology, developing and protecting national innovations, and choices for technology transfer and liaison.

Van Wijk, J. and W. Jaffe (eds.). 1996. Intellectual Property Rights and Agriculture in Developing Countries. Amsterdam: University of Amsterdam.

This collection of workshop papers examines the impact of PVR in developing countries. Farmer perspectives are highlighted and the feasibility of PVR in developing countries is discussed in a number of places.

Chapter 13
Financing Research through Regional Cooperation

Thomas Eponou

Introduction

National governments, donors, and development agencies have long viewed regionalization as a critical means of enhancing the effectiveness and efficiency of agricultural research in developing countries. In Africa, the concept was in use before independence. Both the French and the British, for example, established regional research institutes and networks in their territories for major commodities like oil palm, cocoa, and groundnut. Before the World War II, regionalization was a strategy used by many developed countries to enhance agricultural research (Remenyi 1987).

This chapter highlights some issues surrounding regional financing of research and suggest ways to deal with them. It focuses on what often goes wrong and on what national agricultural research systems (NARS) can do to become more effective and efficient—their major reasons for becoming involved in cooperative regional efforts in the first place.

The chapter aims to help research managers address an often-asked question: How can we share the burden with our neighbors and increase the benefits to everyone through financing regional collaboration? Issues of financing, cost sharing, and accountability are the focus of discussion. These largely determine the success or failure of any attempt at regional cooperation or collaboration.

First, the rationale for regional cooperation in agricultural research is reviewed. This is followed by a descriptive overview of six institutional models currently in use for regional cooperation. Finally, issues relating to funding, costing, and accountability are presented in the latter part of the chapter, along with conclusions.

Rationale and Costs of Regional Collaboration

The current impetus for regional funding of research is based on the potential for enhancing research effectiveness and efficiency through various benefits:

- economies of scale and wider geographical coverage;
- a higher quality of research due to the presence of critical masses of resources and better equipment;
- the exchange of information and the pooling of the experience of professionals in the same field;
- technological spillovers between cooperating countries.

This rationale has become increasingly compelling in recent years for several reasons:

- Many individual national research systems have failed to deal meaningfully with deteriorating socioeconomic conditions and degradation of the natural resource base in their countries.
- The scope of what research needs to accomplish has mushroomed beyond the individual capacity of most NARS to respond. The research agenda is getting heavier as new domains such as natural resources and environmental management become part of their assignment, all during a time of dwindling funding (Nickel 1996).
- The financial crisis in research calls for more efficient use of the limited resources available. Thus, economies of scale must be realized and all potential spillovers must be captured.
- The ecoregional approach is recognized as an appropriate way to deal with emerging issues such as environmental protection and natural resource management.
- The experiences of developed countries in certain areas of public-sector scientific cooperation such as space research have been positive. This has reinforced the belief that developing countries too can benefit from a united regional effort.

The basic rationale and objectives of agricultural research regionalization seem sound in view of the above arguments. But experience to date indicates that actually capturing the expected benefits is not so easy. Several complex and interrelated issues need to be dealt with successfully. These have to do with the goal, mission, objectives, governance, and management of the regional effort, as well as with the resources available to the institution in charge of managing the regionalization process. Other factors, such as members' commitment and the attitude and behavior of donors, are also factors in success or failure. However, the ways in which financial resources are mobilized, allocated, and managed are so critical that they need to be singled out.

Moreover, there are significant costs attached to regional cooperation in agricultural research. The first is the loss of sovereignty over decision making. Resources, for example, may have to be reallocated after the members of a regional structure reach consensus; but the final results will not necessarily reflect what each individual member sees as the best alternative.

Second, as in any cooperation effort, there are transaction costs. These include the time and financial resources used to plan and manage the effort, as well as inefficiencies in resource allocation stemming from other considerations or objectives being taken into account, such as equity.

Finally, it sometimes happens that the participating members don't feel a sense of ownership of activities and achievements. They may somehow feel that they have not been fully involved in decision making and implementation.

Six Models of Regional Cooperation for Agricultural Research

The organizational models used for regional cooperation in agricultural research fall into six major categories. These are described in Table 1. Given the existing and evolving institutional complexity of regional cooperation in agricultural research, the typology may not be complete or perfect. At some point, for example, a particular mechanism may take on attributes of two or three of the others described below. The typology is intended to give readers a general feel for the variety of arrangements and associated activities.

Regional coordination organizations

Clearly specified budgetary contributions from members countries, sometimes supplemented by grants from donors, are the source of funding for regional coordination organizations. These bodies often operate special projects, in most cases fully funded from external sources.

Such organizations often have a mandate extending beyond agricultural research, as in the case of the Instituto Interamericano de Cooperación para la Agricultura (IICA) in Latin America. Sometimes they are specialized bodies pertaining to or linked with other regional organizations with a wider goal. This is true for the Southern African Centre for Cooperation in Agricultural and Natural Resources Research & Training (SACCAR), which is under the umbrella of the Southern African Development Community (SADC); and for PROCIANDINO, PROCISUR and PROCITROPICOS (in English: Collaborative Program for Research and Transfer in the Andean Region, the Southern Cone, and the Southamerican Tropics) which are linked with IICA. The Institut du Sahel (INSAH) in West Africa is an example of a highly formalized regional coordination organization.

Although the initiative to set up regional coordinating bodies has often come from the member countries, they have generally depended heavily on donor funds to operate.

Regional research institutes

This model of cooperation calls for a greater degree of integration among the participating countries since they delegate the responsibility for carrying out research in a specific area to the regional institute. The Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), and the Caribbean Agricultural Research and Development Institute (CARDI) are examples of such organizations. The West Africa Rice Development Association (WARDA) had the same status before becoming a member center of the Consultative Group on International Agricultural Research (CGIAR).

When donors take the initiative to set up a regional research institute, they may provide full financing through grants, as in the case of the Regional Crop Management Research Training Centre at Egerton University in Kenya. But when the initiative comes from member countries, it has the same funding regime as a regional coordination organization. The difference is that a regional research institute can itself generate resources from commercial activities.

Regional associations

Organizations in this category include the Conférence des Responsables de la Recherche Agronomique Africains (CORAF) and the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA). The regional association model has been known in Asia and Latin America for decades but is relatively new in Africa. It is a less structured, integrative form of the regional coordination organization. It focuses more often on the managerial aspects of research and has a simple secretariat, as opposed to the bureaucracy sometimes found in regional coordination organizations. In some cases, regional associations are also in charge of coordinating regional research networks.

Regional associations often get an important part of their budget, especially for special projects, from the international community that encourages them. A portion of funding also comes from the fees of member countries or institutes.

Regional networks

Networking is another major model for regionalization and it is now the most common in terms of numbers. Networks can be classified according to many different traits. The degree of formality, the type of membership, the degree of specialization, or the major functions performed are examples of such variables (Beye 1992, Valverde 1988). The international research centers of the CGIAR, development agencies such as FAO, and members of the donor community have been instrumental in promoting this form of regional cooperation. They also bear almost all of the financial costs, while the participating NARS or national research institutes provide the scientists.

Ecoregional approach

Although the ecoregional approach has been widely discussed, the mechanisms for making it operationally effective still need to be developed or tested. The best example is the Special Program for African Agricultural Research (SPAAR) initiative in Africa. It is generally external to the member countries and, as a consequence, the major sources of funding are also external. But the members, as with other types of regional collaboration, bear the cost of reallocation of human and in some cases financial resources.

Regional professional associations

Individual scientists from the same discipline or cluster of disciplines—for example, plant breeding or crop protection—comprise the membership of regional professional associations. Although the overall goal may be the development of the profession through information exchange, these associations sometimes undertake scientific activities via informal networking. The sources of funding are usually fees from members and self-generated income from, for instance, the sale of publications. However, professional associations often seek external support for specific events, activities, or projects.

Objectives of regionalization

The four major functions or objectives of regionalization are information exchange, coordination, cooperation, and integration (Gijsbers and Contant 1996). Only regional institutes have integration as their objective. The other models usually pursue one of the three others or a combination of them.

It is important to note that a given institution, starting with one of these functions, may add others as it evolves, whether on its own initiative or prompted by donors. Both ASARECA and CORAF, whose initial function was collaboration, may take on coordination tasks as they play a role in the SPAAR initiative for Africa.

All six models have been used as a vehicle for financing agricultural research at the regional level, with the common aims of greater effectiveness and efficiency. Although a thorough review of experiences in Asia, Latin America, and Africa has never been undertaken, the sketchy information at hand suggests that member research institutions and countries do not always meet the expectations of regional structures. The issue of sustainable financing is often the core of the problem.

Table 1. Regional Mechanisms for Research and their Characteristics

Mechanisms	Sources of funding	Major functions / objectives	Activities	Potential benefits	Potential risks	Examples
Regional coordination organizations	Donors Member countries	Coordination	Harmonization of policies, training, funding, and management of network	Access to additional resources and technologies Economies of scale Reduced costs Political support	Political interference in research bureaucracy, and sensitivity to political conflicts External influence on agenda and mandate Difficulties in mobilizing member contributions	INSAH and SACCAR in Africa PROCIs in Latin America
Regional research institutes	Donors Member countries	Integration	Generation of technologies Training	High-quality technologies Enhanced training capacity Additional resources	Pursuit of own agenda Duplication of effort Gaps in technology-generation process because of lack of sustainability Lack of financial support from member countries Friction with national institutions Sensitivity to political conflicts	CATIE in Latin America CARDI in the Caribbean AVRDC in Asia
Regional associations	Donors	Collaboration	Exchange of experiences Collaboration in the area of research management Management of network	Access to relevant information and additional resources and experiences	Misuse of managerial resources Lack of sustainability and political support Difficulties in securing member contributions	ASARECA and CORAF in Africa

continued on next page

Table 1. Regional Mechanisms for Research and their Characteristics (continued)

Mechanism	Sources of funding	Major functions/ objectives	Activities	Potential benefits	Potential risks	Examples
Regional networks	Donors IARCs Members	Exchange of information Collaboration	Management of information flow Generation of technologies	More generic technologies Relevant information Access to additional resources Efficient allocation of resources	Distortion of national priorities by externally driven agenda Misallocation of financial and human resources	INSORMIL WAFSRN in West Africa EARRNET in East Africa
Ecoregional approach	Donors	Exchange of information Collaboration in an ecoregion	Management of collaborative programs Definition of regional strategies in an ecoregion	Economies of scale Reduced costs Additional technologies and resources Capture of spillovers	Externally driven agenda Distortion of national priorities Conflicting agenda and objectives of donors Weak commitment of members	SPAAR initiatives in Africa CONDESAN in Latin America
Regional professional associations	Donors Individual members Own resources	Exchange of information	Organization of professional meetings and other events Publications	Up-to-date information on the profession Steady contact with peers	Poor sustainability due to lack of financial support Control and use by more influential members for other purposes	AAASA in Africa

Achievements through regional collaboration

While systematic studies of the effectiveness of regional institutions and other arrangements are lacking, evaluation of individual institutions shows mixed results. The Programa Regional Cooperativo de Papa (PRECODEPA), for example, was very effective in transferring various potato technologies to farmers in Central America in the 1970s and 1980s (Valverde 1988). It is important to stress that regional efforts, such as those of networks and regional research institutes, have also made significant contributions to human resource development, particularly training (Faris 1991). Finally, the regional institutions have also contributed to strengthening collaboration between the national systems and the international research centers (Elliott 1994, Kyomo 1996).

Funding and Costing

Donor funding

A striking feature of regional collaboration in agricultural research is the large share of the budget made up by donor contributions. In most cases, these are the basic source of funding, and often the only source (though they exclude scientists' salaries). In Africa, for example, national governments barely contributed to financing the more than 160 operational research networks in 1994 (Thiam 1994). The same holds for the funding of regional cooperation institutions such as CORAF and ASARECA. The former is almost entirely financed by France and the European Union; the latter is fully supported by grants from USAID and the World Bank.

The situation for parallel institutions in Asia, Latin America, and the Caribbean, in terms of dependency on external sources of funding, is not much different. For example, donors' share of the budget for a new collaborative initiative under CARDI in the Caribbean countries (PROCICARIBE) ranges from 75 to 100 percent for the major planned activities. Recent cutbacks made by funding sources such as USAID and the Inter-American Development Bank have created the need to seek alternative means of financing regional cooperation in Latin America (IDB 1996).

The heavy dependency on donor funds for regional cooperation is due to the role of donors in setting up most such regional programs. They have either initiated or encouraged the formation of most of the existing institutions. Their reasons for doing this are that financing regional cooperation provides more visibility and economies of scale for grants, and reduces administrative costs because larger grants can be given. A donor can easily justify the way funds are spent because of the focus on a specific theme, and can finance several countries at once through networks without having to manage contacts with the individual countries involved (Lattre-Gasquet and Merlet 1996).

Among other determinants of donor dependency is the fact that managers of research and regional institutions find it is easier to secure funds through grants than by trying to mobilize resources from members. New projects are therefore systematically sent to donors without the possibility of internal funding being explored. This is reinforced by the perceptions of national research managers and policy makers that shifting some activities to the regional level is a way of tapping additional resources from donors.

Although dependency on donors to operationalize regional cooperation has several benefits, some of its significant costs are often overlooked by research managers. These vary from one case to another and according to the donor involved because of differences in funding procedures and conditionalities.

The first cost relates to continuity and consistency in the mission, goal, and objectives of the regional cooperation or collaboration effort. Continuing shifts in the domains of interest and conditionalities of donors may lead to important changes in the initial objectives or mandate of regional structures. Donors have to be innovative in addressing development challenges and must show results quickly to guarantee their own resources. Thus, a regional institution may have to adjust to this reality even when it is not the best solution. Otherwise it may perish. The dilemma of whether to bend the institution to the donor's will and lose some ownership, or to stick to the agenda and risk closing down in a few years, is one of the key issues continually facing managers involved in regional cooperation efforts.

The second cost of donor dependency is funding instability (and, of course, the disruption of operations that goes with it). This can stem from difficulties in managing transitions between donor agencies, from changes in a donor's own budget, or from donor fatigue.

Moreover, dependency on donors creates the impression that they are the ones controlling regional cooperation efforts. Where a single donor continues to provide funding over many years and gets involved in defining the recipient institution's strategy, there may be a strong feeling among members that they have lost ownership. Friction among donors over the regional body's strategy and agenda may also trigger conflicts among member countries or organizations or even affect the internal activities of members.

Finally, donor financing of regional efforts could reduce funds available to individual countries to finance their own program. This is because funds allocated to regional-level activities come out of the total funds available for the region.

Funding from member countries

Member contributions to regional cooperation mechanisms come in various forms, ranging from legally binding budgetary appropriations to the membership fees of individuals (as is the case for most professional associations). But currently, even though the share to be paid by member countries and institutions to the total budget, exclusive of the salaries of contributing national scientists, is often limited, as discussed earlier, mobilizing that contribution is one of the major constraints on effectiveness. INSAH, for example, had severe financial problems in the early 1990s because its member countries were in fiscal crisis and could not regularly pay their budgetary contributions. Declining availability of funds, instability in the funding of NARS, and competing demands for these funds in recent years have increased the number of defaults on payments and aggravated timely release of members' financial contributions. The release of funds by members is also influenced by managerial issues and the degree and type of commitment.

Some problems underlying delays in the release of funds and defaults on payments originate at the planning stage. For example:

- Before joining a regional body, a prospective member country or organization fails to reach agreement with those in charge of its budgetary process.
- Members end up overcommitting their available resources because of involvement in too many organizations.
- The decision to join is based on the financial situation of the moment without an up-front assessment of future prospects for resources. This leads to overly ambitious objectives and plans with regard to the financial resources of the members.
- Long-term commitment of members is not always given high priority during the design stage of regional cooperation or collaboration.

Regional institutions also suffer from managerial inefficiencies in the budgetary processes of member countries. For example, the budget line for the contribution is not always clearly specified, creating administrative friction during disbursement. Or the release of funds is hampered simply because the financial bureaucracy of the member country is complex and inefficient.

Delays in payment and even defaults are sometimes deliberate. Some members take a wait-and-see approach and are unwilling to commit resources until they are convinced they will gain something. This attitude, of course, has a negative effect on regional start-up funding. Managers sometimes fail to understand that continuity is needed in the administration of their own national institution and that they should therefore honor contractual obligations signed by their predecessors. Regional networks and associations, in which there is no political involvement, are particularly vulnerable to such attitudes. Research collaboration, and having to make funds available for it, may be the lowest priority for members since regional institutions have little capacity to exert pressure on them.

A member country may have little or no control over the timing of its contribution. This may be due to foreign exchange problems or to the fact that other countries (e.g., a donor) are funding its participation. The effect of the former problem on mobilizing members' contributions has often been underestimated by research managers during the establishment of regional cooperation programs or institutions. In West Africa, for example, where there are numerous nonconvertible currencies, this problem has more of a bearing on the effectiveness of regional organizations than do linguistic barriers. The West African Association of Agricultural Economists, which folded in the 1980s, is a case in point. The greater the share of the budget provided by member contributions, the more serious the currency problem becomes. This is why professional associations are the most negatively affected, while networks, which are often fully funded from external sources, are the least affected. Many institutions have solved the problem by opening an account in a strong foreign currency such as the US dollar.

Members may also use their failure to pay contributions as a way to express their assessment of the regional effort's performance. They may thus use "exit" rather than "voice" to question performance. But failure to pay may sometimes be due simply to political conflicts. Disagreements between countries have jeopardized the smooth operation of several regional efforts in Latin America and Africa.

Payment delays or defaults create serious problems: declining consistency, continuity, and predictability in funding; loss of control of the agenda by members because of continuing reliance on external resources; friction in the organization; and difficulties in maintaining qualified staff. Over time, delays and defaults create a vicious circle that threatens the survival of the regional cooperation mechanism: as performance declines, members lose interest, their willingness to commit funds dwindles, and performance deteriorates further.

Balancing funding sources: A condition for sustainability

Long-term effectiveness of regional efforts requires funding sources to be balanced. This is also the best strategy for allowing members to take advantage of external resources without losing ownership.

What is the best formula for funding regional institutions, given that they cannot rely solely on member contributions and that heavy external dependency isn't viable in the long run? This is the critical question. The obvious answer is that the share of external resources should decline over time. This strategy also deals effectively with a major constraint on operationalizing regional institutions, namely the need for start-up funds. While this approach has been followed in many cases, the results have often been disappointing. There are several possible explanations for this. First, plans may have been unrealistic, overestimating the long-term capacity of member countries to pay. Second, there may have been no clear strategy on how responsibilities for financing were to be transferred to members. Third, as time went on, new commitments and activities, beyond what members could afford, may have been added.

Some institutions are looking for alternative ways to deal with the problem of sustainability. For example, the Lathn American countries have decided to set up a Regional Fund for Agricultural Technology. To finance the fund, countries pledge resources to an endowment. The return to the endowment is used to finance agricultural research of regional relevance (see also Janssen, Chapter 8 in this book). This will help to stabilize financing of regional initiatives aimed at producing technologies that may be considered regional public goods. The key element is that members' contributions will generate an annual flow of resources to be used to finance the activities independent of the intentions of traditional donors (Inter-American Development Bank 1996). It would be worthwhile for regional cooperation and collaboration programs elsewhere to consider such a strategy.

Recognizing the declining trends in donor funding, CARDI, in the Caribbean, has included a business development project in its strategic plan, allowing it to undertake commercial revenue-earning activities. It has, for example, registered with the Commission of the European Union as a consultancy firm (CARDI 1996).

Preparing a medium-term plan is another way to address the sustainability problem. Covering a two- to three-year period, this should be prepared with the participation of major stakeholders at all levels, and approved at the highest levels of the participating institutions. One option is to request that members release their total contribution for the plan before its implementation. The plan could even include several scenarios over the medium term, ranging from the most pessimistic to the most optimistic.

Estimating costs

Proper costing is essential for success in regional cooperation. Here there are two elements: costing by the regional body itself and costing by the member countries or organizations.

First, the fixed and operating costs need to be accurately estimated by the managers of regional institutions or programs. Unfortunately, they sometimes fail to cost out all the elements required to make the organization fully operational and effective. Resources for meetings or supplies, for example, may be omitted or underestimated in the budget. In some cases, the needed accounting expertise is simply not available within either the member organizations or the regional institution itself. Here it is advisable to secure the necessary expertise, even on a consultancy basis, since the extra financial costs incurred by bad estimates can be several times higher than the fees paid to a good consultant.

There are other reasons why managers fail to make proper cost estimates. They may find the task too complex, they may lack the information base, norms, and standards needed to prepare budgets, or they may be reluctant to invest the time needed to collect accurate information. These are phenomena often observed at the national level. Such issues are discussed in other chapters of this book.

Unstable exchange rates and high inflation also make costing a difficult exercise, reinforcing the need to use the services of specialists. Both individual member organizations and the regional institution or mechanism should make provisions to deal with such contingencies.

It must be stressed that poor costing can also result from a lack of realism on the part of those who plan regional institutions or programs. In some cases, funds have not been secured through projects as expected, or members have been unable to meet their financial obligations. In Africa, the budgets of regional institutions or associations have sometimes been designed in such a way that mandatory events (those dictated by the institution's charter) are supposed to be funded from local contributions. When the money doesn't materialize, the event has to be postponed until the secretariat can find a donor willing to help. Developing a detailed and exhaustive medium-term plan can help to minimize the impact of such costing errors.

The second costing dimension relates to what each individual member has to contribute to make the regional effort effective. At the design or planning phase, managers of individual member organizations should realize that besides direct costs, regional cooperation has indirect financial or economic costs. These include transaction costs as well as the opportunity costs of allocating resources to regional cooperation rather than something else.

Some costs, like staff time for meetings, only become obvious to managers during implementation. These can be quite high, especially for small countries and those facing serious resource constraints. For example, the national breeding program for a particular commodity may be seriously undermined if the sole breeder in the national system is heavily involved in a regional network. In the case of regional coordination organizations, national managers and individual scientists may have to spend several valuable days a year in meetings, with limited outcomes or benefits for their research systems. A regional program or institute may also undermine national efforts by draining off the best national scientific talent because it offers better working conditions.

There are several reasons why participation in regional cooperation is not always fully costed out:

- lack of awareness;
- a general attitude among institutions, countries, and individuals that "it is always better to be in than out;"
- a tendency to focus more on the expected gains than on the costs when making such decisions;
- managers' fear of being seen as uncooperative;
- failure of members to seek inputs from financial specialists, especially at the design phase.

As the costs of participation become obvious during implementation, managers of member institutions tend to minimize these costs by restricting their involvement in some activities. This often results in unnecessary friction with those in charge of managing the regional cooperation program or even among members. The most realistic solution is a transparent, detailed, and full-costed medium-term plan, prepared in a participatory manner. The benefits and costs for each member must be explicit.

Cost sharing

Cost sharing in regional cooperation is a complex issue with two distinct components. The first has to do with finding an equitable formula to define the contribution of the members. Should all contribute evenly? Should the formula be based on capacity to pay? Should contributions be voluntary? How should members' shares evolve over time given that the initial parameters used to define these shares will also change? The answers to these questions may have a strong bearing on how much influence specific members exert over decision making.

The fear of members not having an equal say in regional cooperative efforts—or an equal share in their benefits—has often led to a policy of equal sharing of costs, even though capacity to pay varies widely from one country or institute to another. While the preoccupation with equitable sharing of influence and benefits is real, the policy of equal contributions can hinder the effectiveness of cooperation as some countries will not be able to meet their financial obligations. To avoid these thorny issues, most institutions prefer a strategy whereby each member pays only a small but equal share of the budget, with the bulk of funding requirements being requested from external sources. Here the politics of equity are pursued at the expense of the long-term health and survival of regional cooperation.

The second aspect is cost sharing between members and international organizations, such as CGIAR centers which are also funded by donors. This issue is particularly relevant for some regional research networks. The rationale for asking for financial contributions from member countries or institutes is not always evident since donors may already have given the international research centers resources specifically for that purpose. Moreover, the nonfinancial costs borne by the members are often forgotten and that sometimes creates friction.

Accountability

To be accountable is to demonstrate in transparent fashion that mandated goals and objectives have been achieved through the efficient and legal use of resources. Like any public institution, regional cooperation institutions and programs must be accountable if they are to secure sustainable funding. Accountability also promotes healthy dialogue among stakeholders, especially investors, coordinating institutions, and clients.

In this context, it seems essential to demonstrate the following elements: output, impact, equity, sound financial management, and efficient and correct allocation of resources. The last two are extensively discussed elsewhere in this book.

Accountability has to do with defining lines of responsibility—making clear which bodies and individuals are in charge of managing cooperative and collaborative efforts and executing decisions at various levels. A key prerequisite is that the incentive and sanction system for regional cooperation be in line with the responsibilities at each level, whether within the regional body itself or within participating countries.

The dilemma of accountability is that while all stakeholders want it, they do not use the same criteria of institutional performance and issues regarding its measurement are still unresolved (Holzer and Halachmi 1996). It seems highly prudent to set up monitoring and evaluation systems that cater to the interests of all stakeholders. This will have the advantage of maintaining a dialogue with them and ensuring their continued support. These systems should be built right into the initial design of regional cooperation initiatives. It is an area of management that deserves more consideration than it has been given in the past, especially since investors are becoming more and more demanding. While in some regions farmers and their organizations have previously been quite passive, they are now beginning to exert pressure on research organizations. Increased accountability may even become their primary condition for contributing funds to agricultural research (Eponou 1996).

What should regional institutions be held accountable for? Should their performance be measured within the institution itself? At the level of outputs and their effect on member organizations? Or at the grass-roots level of technology application by end users in the participating countries? The trend is to assess performance at all levels; accountability thus demands the use of different criteria and indicators depending on what is being measured. What is important here is to find efficient ways of measuring performance that aren't a drain on financial and human resources. Regional cooperation and integration would benefit from the integration of accountability measures used at the national level into a regional system of monitoring and evaluation.

Concluding Remarks

Regional cooperation, if well designed, is an appropriate instrument to increase the effectiveness of research spending. It has been successful in those instances where it dealt with research questions common to several countries but too big for a single country to tackle. However, there are other reasons for its popularity in recent years. Regional cooperation also provides a tool for political integration, favoring internal cohesion and harmony among participating countries and increasing the region's negotiating position with countries or initiatives. It has also been a favored tool among donors and international centers because it decreases their costs of interacting with the region and is compatible with the pro-integration policies in donor countries.

Regional cooperation is often funded or even initiated by donors, and thus may be biased toward their interests rather than those of the participating countries. Once the initial donor withdraws, financial sustainability may become threatened. It is recommended that even in the initial stages of regional cooperation, countries undertake at least a few activities at their own cost to ensure domestic approval (e.g., by the treasury), to establish internally driven coordination, and to secure the commitment of other member countries to the initiative. Balanced financing is the key to sustainable regional cooperation.

In the design of regional cooperation, some issues need special attention. Costing of research may be complicated by variable exchange rates or limited convertibility of currencies. Costing should reflect not only operational requirements, but also the time spent by participating researchers. Cost-sharing formulas need to take into account the expected benefits to different member countries, difficult as it may be to establish the required criteria.

Regional cooperation institutions and programs are accountable to more than one government (e.g., the donor country and the member countries). This requires that they either fulfill the separate requirements of all participating countries, or that a common accountability standard is agreed on in advance. How to measure accountability is another question. This may require interaction with users in different member countries. If accountability is not measured at the level of the end user, then regional cooperation efforts run the risk of remaining highly abstract—of interest more to researchers than to the user community they should be serving.

Regional cooperation thus allows for cost sharing and improved effectiveness. But it has to be recognized up front by prospective participants that there are additional costs and efforts involved compared with national research. If these are adequately factored in, then realistic models for regional research may continue to develop—arrangements that are attractive to both domestic and external investors.

References

Beye, G. 1992. Strengthening National Research Systems through Regional Technical Cooperation. Paper prepared for the International Workshop on Management Strategies and Policies for Agricultural Research in Small Countries. Mauritius, 20 April - 2 May, 1992.

Elliott, H. 1994. Coordination of Research: Issues, Experiences and Lessons from Africa. Paper prepared for the SPAAR Workshop on Regionalization in Agricultural Research in West and Central Africa. Banjul, March 14-18, 1994.

Eponou, T. 1996. Partners in Technology Generation and Transfer: Linkages between Research and Farmers' Organizations in Three Selected African countries. Research Report No. 9. The Hague: ISNAR.

Eyzaguirre, P. 1996. *Agriculture and Environmental Research in Small Countries: Innovative Approaches to Strategic Planning*. West Sussex: John Wiley & Sons.

Faris, D. 1991. Agricultural Research Networks as Development Tools: Views of a Network Coordinator. Patancheru, India: ICRISAT.

Gijsbers, G. and R. Contant. 1996. *Regionalization of Agricultural Research: Selected Issues*. Briefing Paper No. 28. The Hague: ISNAR.

Holzer, M. and A. Halachmi. 1996. Measurement as a Means of Accountability. *International Journal of Public Administration* 19(11/12):1921-1943.

IDB. 1996. Toward a Regional System of Technological Innovation for the Food and Agricultural Sector. Washington, DC: Inter-American Development Bank.

Lattre-Gasquet, M. and J. F. Merlet. 1996. Agricultural Research Networks in Sub-Saharan Africa: An Analysis of the Situation and Its Consequences. *Knowledge and Policy: The International Journal of Knowledge Transfer and Utilization* 9(1):36-48.

Kyomo, M. 1996. The Globalization of Agricultural Research: The Example of Southern Africa. In *The Globalization of Science: The Place of Agricultural Research*. Eds. C. Bonte-Friedheim, and K. Sheridan. The Hague: ISNAR.

Nickel, J. 1996. A Global Agricultural Research System for the 21st Century. In *The Globalization of Science: The Place of Agricultural Research*. Eds. C. Bonte-Friedheim and K. Sheridan. The Hague: ISNAR.

Remenyi, J. 1987. Partnership in Research: A New Model for Development Assistance. Paper prepared for the Fourth World Congress of Social Economics, Toronto, 13-15 August 1986. Canberra: Australian Centre for International Agricultural Research.

Thiam, M. 1994. Status of Regional Research Networks in Sub-Saharan Africa. Washington, DC: SPAAR Secretariat.

Valverde, C. 1988. Agricultural Research Networking: Development and Evaluation. Staff Notes No. 88-26. The Hague: ISNAR.

Recommended Reading

Eyzaguirre, P. 1996. *Agriculture and Environmental Research in Small Countries: Innovative Approaches to Strategic Planning*. West Sussex, UK: John Wiley & Sons.

This book deals with the special issues of agricultural research in small countries. Since such countries often lack the capacity to solve research problems, or have only limited capacity, strategies for regional cooperation are highly relevant. The book raises an important issue: because these strategies can rely heavily on the efforts of small numbers of staff available in small countries, their advantages and disadvantages need to be clearly defined.

Gijsbers, G. and R. Contant. 1996. Regionalization of Agricultural Research: Selected Issues. Briefing Paper No. 28. The Hague: ISNAR.

This briefing paper provides a concise overview on the different considerations involved in pursuing regional research.

Lattre-Gasquet, M. and J. F. Merlet. 1996. Agricultural Research Networks in Sub-Saharan Africa: An Analysis of the Situation and Its Consequences. *Knowledge and Policy: The International Journal of Knowledge Transfer and Utilization* 9(1):36-48.

The authors provide a critical analysis of the motives and the cost-effectiveness of agricultural research networks in sub-Saharan Africa.

Bonte-Friedheim, C. and K. Sheridan (eds.). 1996. *The Globalization of Science: The Place of Agricultural Research*. The Hague: ISNAR.

This book brings together essays by authorities in the field of research management on how agricultural research will develop in an increasingly interconnected world. Changing modes of cooperation is one of the books recurring themes.

Part 3
Financial Management

Hilarion Bruneau

Financing and resource mobilization mechanisms have their requirements and limitations. Both lead to the need for wise stewardship of the financial resources already acquired and entrusted to the institution. In times of insufficient or uncertain funding, good financial management becomes even more critical. The first response to tight funding should be to manage well what is currently available.

The belief that it is easier to increase outside funding than to fix an institution's internal financial problems leads to inefficiencies and poor performance. Approaches to resource management based on this belief are increasingly unpopular with donors and other investors. Because inadequate or insufficient funding is just one among many causes of the problems facing agricultural research organizations, identifying and tapping new funding sources is no magic bullet. Wise management of available funding is critical to achieving agricultural research results, increasing the contribution of traditional funding sources, and attracting and developing new sources.

In attempting to attract or even retain funding, agricultural research has heavy competition from other social and economic interests and demands. Investors have become increasingly selective about what they will fund and, more than ever, funding depends on performance and results. Investors are guided in their financing decisions by their commitment to obtaining value for money—that is, getting quality products or outputs at a reasonable cost.

In publicly funded organizations like NARS, how money and operations are managed is a more important criterion of institutional performance than in private firms. In the private sector, a firm's main objective is to make profits. That is the bottom line. As long as the shareholders are satisfied with the financial return on their investment, they are unlikely to interfere very much with the way managers use funds or get the work done. In contrast, a NARS, being a non-profit public entity, cannot rely on such a bottom line as proof of success and impact. Rather, the quality and usefulness of its research results, plus the way it has used public money to get those results, become the focus of attention. Moreover, the heterogeneous nature and large size of the agricultural research organization's constituency intensifies this scrutiny. To respond adequately to the many, sometimes competing interests of farmers, consumers, government ministry officials, and donors, and to satisfy them that their public money is being spent wisely, great attention must be paid to financial management.

The economic climate, the growing concern over the productivity of public services, and the revolt of taxpayers are putting pressure on NARS to improve financial efficiency in the delivery of agricultural technology and research services to the community. Reaching a high level of performance is made easier if good financial management practices are in place.

Successful resource mobilization and sustainable financing are not possible without sound financial management. To secure a steady flow of funds, NARS must not only do a good job of managing the resources they already have, they also need to demonstrate their competence in financial matters to investors and other stakeholders.

The thinking on financial management has been shaped largely by the literature on general business. Believing that the problems of financial management in NARS are totally different from those found in other management settings is a mistake. However, the implementation of general business practices without proper consideration for the specific conditions found in individual NARS has proven costly in many instances. There are numerous opportunities for NARS to share solutions and experience with the general business sector, particularly in financial management. But successful sharing implies careful adaptation.

This chapter aims to improve understanding of financial management principles and practices and their support role in the wider management context of developing-country NARS. It is also meant to give guidance to agricultural scientists and research managers in the setup, operation, and maintenance of good financial management practices. It examines the process of managing money in research institutes and how good financial management can enhance the performance of agricultural research while optimizing financing and resource mobilization. The chapter presents money management as a process and subsystem in NARS and outlines problems and solutions at the various stages of the financial management cycle.

Readers are introduced to the internationally accepted vocabulary of financial management. Knowing this language will improve the agricultural research community's communication with the external investor community, particularly officers in the finance ministry, treasury, and other funding agencies.

Chapter 14
Principles and Practices of Good Financial Management

Hilarion Bruneau

Introduction

The Financial Management Cycle

Simply put, financial management has to do with putting money to work in an orderly way to accomplish defined tasks. In the context of a NARS, it is a management subsystem whose purpose is to help research managers and other stakeholders in agricultural research to plan and manage the deployment of resources effectively and efficiently. In so doing, good financial practices improve the generation and delivery of agricultural technologies. They can also help the research system to acquire a degree of financial autonomy, thereby taking the strain off the national budget.

As the money needed to do agricultural research is in limited supply, its use must be optimized. With growing competition for scarce resources, it isn't surprising that investors and taxpayers who supply the funds are demanding greater transparency in, and accountability for, their use.

Financial management, often abbreviated to FM in the rest of this chapter, can be represented as a cycle of six interdependent core actions or steps. These apply to both public and private organizations, although the way they are implemented differs from one institutional context to the next. Figure 1 depicts the actions in the cycle:

- appraisal of funding needs and availability (financial planning);
- acquisition and management of funds (financial strategies);
- allocation of funds (budgeting);
- use of funds (financial policies, systems, and procedures and treasury management);
- control of funds (financial analysis, internal control, and auditing);

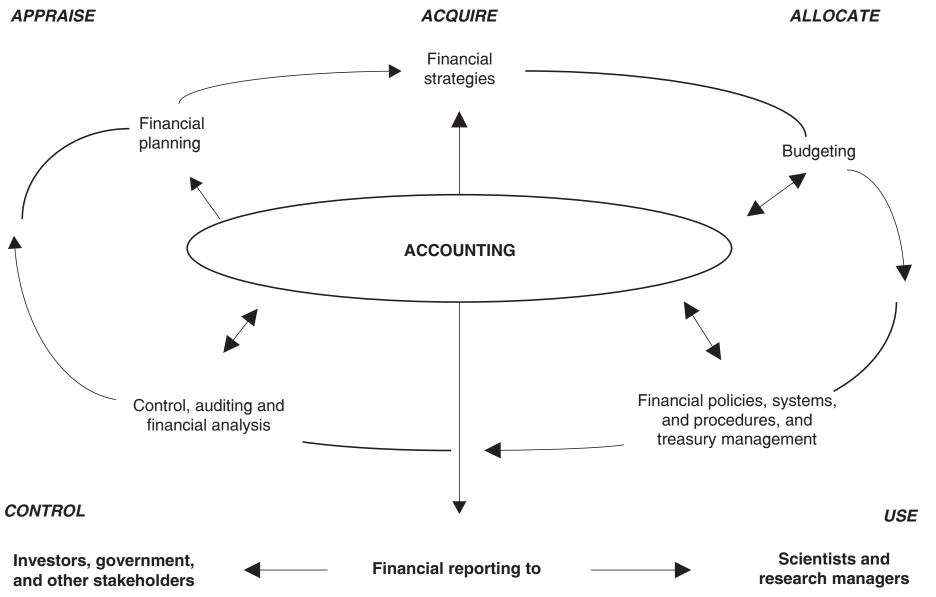


Figure 1. Financial management cycle

- accounting (accountability).

For our purposes, FM takes place within an agricultural research system or organization. It requires human, physical, and financial resources and competes with other institutional subsystems for those resources. It must, however, be closely linked to the other subsystems. It has its own structure and nomenclature, and requires knowledge and know-how.

FM is considered weak in many developing-country research systems. There are several reasons for this, among them the following:

- FM tends to be assigned low priority in NARS.
- FM practices are adversely affected by traditional public-sector management approaches that emphasize control rather than management.
- Staff with appropriate FM qualifications and capabilities are in short supply.
- The fragmentation of the NARS makes it difficult to develop sound FM practices.
- In some countries, donor reporting requirements take priority over the development of institution-wide FM practices.

In this chapter, the main elements of the financial management cycle are discussed from the perspective of how they can help NARS managers in the intricacies of capturing funds and optimizing financial efficiency. Annex 1, at the end of this chapter, presents a checklist for evaluating the soundness of financial management within a NARS, based on questions a prospective investor might ask.

Financial Planning

Financial planning attempts to answer two fundamental questions: How much money is needed? How much is likely to be available over the long term for agricultural research? It consists in an assessment of agricultural research programs and financial resource requirements, conducted in light of the forecasted availability of funding. Financial planning serves as a practical test of the research plan and is a key mechanism in support of funding requests to prospective donors and other investors. A good financial plan and planning process provide a framework for informed discussions between research leaders and their financiers.

Good FM systems and practices make it easier to translate research plans into sound institutional financial plans by supplying the necessary financial data and other information. They also enhance the financial credibility of the research institution, its scientists, and research program managers, especially in meetings with politicians, treasury officials, donors, and other investors.

Financial planning begins with a study of the institute's long- and medium-term research plans. These are compared with the needs of research programs and of the institution as a whole, i.e., stations, laboratories, and other units. Useful information for financial planning includes national economic trends, funding trends, past and present financial situations, institutional budgets, and cost-accounting data on current and future agricultural research. Financing may be divided into the following pattern or categories:

- institutional support (unrestricted core requirements to cover the resource needs of research activities),
- targeted (for identified programs or some specific restriction or reporting requirements),
- miscellaneous (for other activities, services and revenue).

Table 1 gives an example of how a research plan can be translated into a financial plan.

The appraisal of financial needs, then, involves the transformation of agricultural research plans and institutional needs into a coherent and practical financial plan that clearly spells out requirements. Many NARS have well-prepared agricultural research plans, but few take this extra step.

The CGIAR Secretariat has developed a matrix for planning and financing research activities that aims to make financing more predictable while improving the transparency and accountability of the research itself. The matrix provides a quick glance at activities by programs (columns) and research centers (rows). The financial data for a NARS could well be presented using an adaptation of this matrix.

Table 1. Long-Term Financial Planning (5 to 10 Years), Requirements, and Sources for a NARS

	How much money is required?		How much money is available?	
Long-term financial plan will answer the questions	***Operation*** **Recurrent costs**	***Capital*** **Investment or capital costs**	***Operation*** **Financing for research execution**	*Capital* **Financing for investments or capital costs**
To achieve the objectives of agricultural research programs and projects (direct costs of research execution).	Categorized by research programs and projects and/or by nature of expenses (personnel, training and seminars, supplies, inputs).		Financing sources (grants, loans, research contracts) categorized by type of provider (donors, grantors, contractors).	
For program management, support, and maintenance of facilities, i.e., stations and laboratories (costs of management and support services units, maintenance, and utilities).	Categorized by units (DG's office, scientific directorate, finance) and/or by nature of expenses (personnel, supplies, maintenance, utilities, communications, and insurance).		Miscellaneous income from sales of products and services, categorized by units (programs, projects, stations, laboratories) and/or by source of income (seeds, plants, products).	
For development, long-term training, consultants, new facilities, installations, equipment.		Fixed assets and capital costs of facilities and installations. Vehicles, equipment, construction, civil works, development, training.		Financing sources for investments and capital, development grants, and loans.
To ensure solvency, viability, and uninterrupted cash flow and to accommodate against contingencies.		Cash flow and reserve requirements for contingencies, research financing funds, etc.		Financing sources for cash flow, reserve, and contingencies. Investment income.
Total	***Operational needs***	*Capital needs*	***Availability***	***Availability***

	Funding proposal for research programs of an institute					
Region / center / station	**P1**	**P2**	**P3**	**P...**	**Pn**	**Total**
Region A						
Center B						
Station C						
Laboratory D						
Others ...						
Total for Institute						*Funding*

(See recommended readings, CGIAR Secretariat, for more on a funding proposal matrix.)

The long-term financial plan is a summary of the financial requirements and strategies of a NARS for a 5- to 10-year period. Financial requirements should be abstracted in the form of a financial report that clearly states the assumptions and hypotheses used in preparing the financial plan and implementation strategies.

Financial Strategies

The funding environment is becoming highly entrepreneurial and NARS can no longer rely entirely on automatic transfers from their national treasuries to cover all needs. Thus, research strategies have to be supported with financial strategies for acquiring and managing the funds needed to do research. These have become a crucial ingredient in the overall enterprise of agricultural research.

NARS clearly have many options in this regard; indeed, it is an area in which they should be proactive. As they obtain more freedom in the planning and implementation of agricultural research, they are also expected to be more self-sufficient. FM strategies that can help enhance NARS financing are presented below.

Funding submissions

NARS managers can generally improve the quality of their formal submissions to authorities in the finance ministry, the treasury, and planning departments, as well as to donors, credit grantors, and other investors. The key is to understand financiers, speak their language, and meet their requirements. Other parts of this book provide useful advice in this area.

Self-financing

As discussed in earlier chapters, there are many ways for a NARS to generate funds. Examples include selling research products, by-products, and services; taking on research contracts; and exploiting underutilized or idle assets. While NARS managers should try to retain the proceeds of various self-financing measures, this usually requires changes in public-service financial regulations—changes that acknowledge the public's wish for more productive and efficient public institutions. Accounting and reporting practices should disclose the net contribution of such entrepreneurial measures to the operations of the NARS. Treasury officials and financiers in general will be interested in self-help measures. However, self-financing should never detract from the basic business of agricultural research.

Streamlined contracting and billing

Improving the way these are handled can help optimize the capture and flow of funds. In particular, the format and timeliness of reports and invoices can often be enhanced, along with procedures for following up on advances and receivables. As the amount of contracting for research services increases, there is a strong need for professionalism in these areas; in fact, specialized services within the research system may be needed. NARS should ensure that billings include all costs covered by a contract or project agreement. Rapid billing and collection of receivables are indicators of financial concern and effectiveness.

Overhead charges and recovery

Research managers need to be informed of current trends in overhead recovery rates and mechanisms. This issue is taking on extra significance as funding becomes more competitive and project-related. Overheads cover general institutional expenses, as opposed to the direct costs of producing specific goods and services. Common overhead items include governance, such as the board of trustees and director general's office, and common services such as finance, personnel administration, computer support, laboratory services, information services, public relations, maintenance, and security.

Overheads, if too high, can discourage prospective clients or undermine relationships with investors. As financing moves towards restricted or specific-project funding, every effort should be made to shift expenses from overheads to direct costs. A rule of thumb is that if 75 percent of the costs accumulated in one expense account can be allocated directly to a project, then this account shouldn't be part of overheads, but allocated entirely to the project. To improve transparency in financing, research projects should be billed with all their related costs specified (full-cost allocation). Direct project charges should be considered for support staff, computer services, financial services, utilities, and other items. However, despite efforts to identify direct costs and minimize overheads, there will always be a practical need to group small indirect expenses into a chargeable overhead rate.

The overhead rate can be based on the annual budget for the coming year and revised annually. It should, of course, be reasonable from the financier's point of view, but the acceptable rate will vary from one funding source to another. The minimum rate should be dictated by an analysis of the costs and revenues of a specific research contract or project (Cost-Volume-Profit-analysis) and the maximum by what the provider of funds has agreed to bear. One way to reassure donors and other investors is to request that the overhead rate be examined and confirmed by the external auditor, as part of the year-end financial audit.

Budgeting

The next step is to prepare a short-term financial action plan that matches research priorities with the level of funding expected in the short term. Budgeting "is translating the operational short term agricultural research plans into financial terms so that limited available financial resources can be applied in the most efficient manner to carry out the agricultural research activities described in that plan" (Nickel 1989). As a management tool, budgeting can serve to

- communicate goals and objectives to all staff;
- optimize resources and impact (get the right things done at the right time);
- coordinate efforts and activities;
- motivate personnel to meet objectives;
- anticipate and avoid financial difficulties;
- ensure funds are used for institutional objectives.

Budgeting in NARS is seldom used for all these purposes. It is mainly used for control (the last two items). A review of budget-related problems in NARS might reveal the following :

- Budgeting takes place largely outside the NARS, as a function of government ministries or projects. Internal contributions to the budgeting process are reactive rather than proactive, following ministry guidelines. Research staff are only minimally involved. There is no budget committee or formal consultations and the process relies on the fund-raising capabilities of the director general.
- The budget is not prepared on the basis of planned research activities. Rather, it is based on the control of inputs by line item.
- The approved budget is not communicated to staff. It remains a well-guarded secret.
- How money is spent is not monitored since this surveillance responsibility is not clearly assigned to persons in charge of budget execution (budget holders). Any problems that arise are handled by crisis management.
- There is either no budget calendar, or else the one in use is out of synch with the agricultural research cycle. In the latter case, the national budgeting calendar is often used by default.
- There are no budgeting procedures, standards, or norms in place. Or, where such guidelines do exist, there is no manual explaining them.

- The NARS budget is fragmented, consisting of numerous subunit budgets, with no consistency in the time period they cover and presentation of data.
- Financial data for analysis and preparation of the budget are lacking, and accounting and cost accounting systems are poor. Budgeting and accounting are not integrated, codes used for budget preparation differ from those used for accounting, making budget preparation and monitoring more difficult.

These problems generally have to do with a history of over reliance on external public-service structures to handle financial matters and with weak knowledge of the budgeting process as a managerial tool.

In some NARS, the budget itself is submitted as an optimistic funding request, a practice that can create serious confusion. The funding request is essentially a planning tool; the budget is a working tool. Conflating the two can lead to misunderstandings between treasury officers, research managers, and researchers. Treasury officers or investors, expecting a realizable financial action list from the NARS, are presented, instead, with a financial wish list. Researchers' expectations are not met, they feel powerless and frustrated at having to adjust, and they develop a negative attitude to budgeting. This may lead to a weakening of researcher participation in the budgeting process and a distrust of the NARS in its management of budgetary matters.

Standard costs and norms for research activities and supplies are needed for proper budget preparation and to evaluate the efficiency of budget execution. However, it is not easy to establish ones that meet with wide acceptance. Costs vary according to the type of research activities and the place or region where research is conducted. With regular use and review, standards and norms will become increasingly accurate and gain wider acceptance. When of good quality, they form a sound basis for decision making and increase the credibility of those presenting and justifying a budget to decision makers.

For an institution to develop an internal culture of financial responsibility, budget holders need to be evaluated on the results of budget execution. This means that the costs included in a project budget and for which a budget holder is responsible must also be under the control of the budget holder. This is generally the case for direct project costs. Indirect costs and overheads related to a research project are usually not under the control of the budget holder, but they should be clearly identified in the budget.

Table 2 presents a 12-step timetable for successful annual budgeting in a NARS. Note that the process kicks off in March, 10 months before the start of the actual January-to-December budget year.

Table 2. Annual Budgeting Timetable for a Semiautonomous NARS

Action	Time frame	Task
1. Plan	March (10 months before start of budget year)	Update the budgeting procedure and prepare circulars and forms for the coming budget year. Ministerial budget circulars and forms received should be distributed to budget holders (staff responsible for a budget). Provide estimates of available finances and needs (capital/investments and operations). The financial plans and funding request, together with past results and current budget data, should provide indications. Organize budget preparation steering committee. Plan data collection and meetings for budget preparation.
2. Coordinate	April	Budget preparation steering committee meets to decide on and adopt the budget preparation procedure.
3. Distribute	May	Distribute circulars and forms to budget holders. Budget holders inform their staff of the ways and means of budget preparation for the coming year.
4. Prepare	June	Budget holders collect data within their budget unit, review and/or complete budget forms, consolidate data, and forward to budget coordinator. The data should include governmental and other financing, by research program, project, and activity, and provide financial information by region and nature/categories of expenses (line item public-service categories).
5. Analyze	July	Budgeting committee analyzes the budget proposals. Estimates and justifications of proposed expenses and revenues and estimates of government and other grants are compared with previous financial and budgetary results. Coherence of plans, priorities, and costs are examined. Stage regional meetings with budget holders and staff for analysis and discussions.
6. Approve	August	Revise budget proposal, check calculations, and consolidate information. Prepare an operational or activity plan: research operations and proposed budget by activity and timing, by expenses and revenues, and by cost center, research program and/or units and budget holders. Budget coordinator prepares a detailed analysis of the consolidated budget proposal. Approval by budget committee (internal).
7. Present	September	Present, defend, and negotiate budget proposal before the board of trustees (administrators) and ministerial authorities (agriculture, finance, or others).
8. Adjust	October	Budget committee meets, discusses, and requests budget holders to adjust their budget proposal and operational plan according to the results of presentations and negotiations.

continued on next page

Table 2. Annual Budgeting Timetable for a Semiautonomous NARS (continued)

Action	Time frame	Task
9. Submit	November	Submit for board, ministerial, and parliamentary approval (external).
10. Notify	December	Notify staff in charge of budget execution (budget holders) of the approved budget and request that budgetary information be passed on to the staff of their budgetary units. Input budget data in the accounting system (budgetary accounting).
11. Monitor	January-December (monthly during budget year)	Execute budget and monitor budget execution at the end of each month and analyze variances.
12. Amend	June of budget year	Discuss budget execution and variance. Arbitrate and modify budget. Present and distribute amended budget.

The implementation of such a budgeting process requires the following:

- Commitment: Top management determination to master the process.
- Know-how: Knowledge of the budgeting process within the institution.
- Good information: Integration of budgeting and accounting, development and use of accurate cost standards, and budgeting over three to five years.
- Leadership: A qualified person in charge of the budgeting process.
- Strong linkages to programming: Participation of researchers in budgeting.
- Project mode of operation: Clarification of responsibilities for budget execution and evaluation of personnel based on budget execution.
- High-level support: Backing of treasury and ministerial authorities.
- Funding: Money to manage and operate the budgeting process.
- Good logistics: Office space, equipment, computer services, and transport.
- Expertise: Technical assistance if necessary.

Many NARS use their budget for control purposes only. But a budget can be more useful than that. It is a practical day to day business tool that can help scientists, program leaders, and other managers to achieve research results with greater efficiency and effectiveness. Being able to anticipate and avoid financial difficulties is mainly the product of good budgeting practices.

The budget can also be an effective instrument for coordinating and communicating agricultural research plans, for motivating staff, and for evaluating their performance. When used for these purposes, it is important that staff be asked to participate in budget formulation.

Monitoring the budget enables a NARS to compare results with plans and to make the necessary short-term adjustments. If scientists, program managers, and the general staff can see that they are operating effectively and within budget, they will be more motivated to accomplish their tasks. The budgeting process should be mission-driven, participatory, decentralized, and result-oriented. Sound budgeting is critical to getting research financed and completed.

Financial Policies, Systems, and Procedures

Executing a budget is easier when NARS managers provide guidance to their staff about the policies, systems, and procedures that have been put in place to manage research operations and resources. FM in government or quasi-government organizations, such as national agricultural research institutes, has historically been aimed at strict control over the use of funds. This approach resulted in procedures for the use of public money becoming so complex that users simply avoid them as much as possible. This phenomenon is described by Osborne and Gaebler (1993): "In making it difficult to [misuse] or steal the public's money, we made it virtually impossible to manage the public's money."

Many NARS, suffer from too many financial controls which end up stifling research. For NARS to become more entrepreneurial, there needs to be a shift in emphasis, away from rigid control over expenditures (the "funding input" system), toward the promotion of more productive use of resources (the "funding output" system). This doesn't mean that financial controls should be abandoned, but that a different approach is needed, one that stimulates researchers to do their work well instead of discouraging them.

Keeping the spending process simple and providing adequate cash flow are two key ways to help scientists get their research done. In this respect, practical policies, systems, and procedures, written up in clear language, are proven tools of good FM. By clarifying and assigning responsibility—namely, who may handle funds and under what conditions—they provide an encouragement to act. For example, a simple and practical instrument is the petty cash fund. This allows staff members to make small but sometimes urgent purchases that were not foreseen. Without such a fund and adequate policies and procedures governing its use, small problems like a broken component in a piece of equipment can bring progress on a research experiment to a grinding halt.

The policies, systems, and procedures laid down by management to govern the research institution's operations, including the use of funds, are often compiled into a manual. Here are typical components of such a document:

- mission statement and strategy of the NARS;
- general policies, systems, and procedures;
- organizational chart;
- staff manual and personnel procedures;
- program and project administrative circular and procedures;
- station management and physical facilities management; procedures;
- laboratory management procedures;
- financial and accounting procedures;
- purchasing procedures;

- computer use and procedures;
- publication and printing procedures;
- information management procedures.

Many research organizations do not have manuals explaining policies, systems, and procedures. Of those that do, there are often problems with access, use, relevance, and the quality of presentation. Manuals should be well-edited and readily accessible to staff (for example, by ensuring there are copies in the library or on the internal computer network).

Financial resources are used more effectively when scientists, research managers, and financial managers or advisors work closely as a team. As noted above, more emphasis needs to be placed on funding outputs rather than inputs. Bureaucratic hurdles should be minimized and staff encouraged to get results. Internal financial audits can be used to identify ways of streamlining procedures and encouraging results. Responsibility for the use of funds should be clearly designated, and authority to spend should accompany that responsibility. Spending procedures should be simple; for example, a single, all-purpose form should be used for spending requests, purchase orders and authorization, receiving reports, budgeting, accounting, and payment. With one document, users become more familiar with financial management processes and the management burden is reduced.

There are simple and practical indicators of the use and ease of use of financial resources. One of these is the existence of a petty cash fund, as mentioned earlier. The monthly review of budget execution (action 11 in Table 2) provides extensive information on how financial resources are being used. If there is no spending on a research program, it is likely that very little is being achieved.

In summary, making funds accessible and easy to use demands good communication, knowledge, responsibility, and control. Research managers need to communicate clearly to staff the ways and means that have been chosen to ensure that financial resources lead to the achievement of research objectives. This can be done verbally or in writing, though there is a consensus that written policies, systems, and procedures are more effective. Users learn more, and faster, when good support literature is available.

Thus, good administrative communication in agricultural research promotes good FM practices. In turn, the positive image projected by the institution enhances its credibility in financial matters and increases the chances of a positive response to funding requests.

Control, Auditing, and Financial Analysis

Management control is a participative process by which managers ensure that institutional resources, including funds, are obtained, safeguarded, and used effectively and efficiently to achieve organizational objectives. *Internal control* has to do with the structures and systems put in place to ensure sound management of the organization.

Basics of financial internal control

A basic principle of financial internal control is the segregation of responsibilities. Following this principle, the processing of any financial transaction should involve the intervention and approval of more than one person in the institution, including senior managers. In particular, the functions of authorization, processing, recording, and payment should all be segregated. Where the same accountant is responsible both for procurement and for accounting and disbursement of funds, for example, there is inadequate segregation. Similarly, accounting records should not all be under the control of one accountant. The principle of segregation of responsibilities is one reason why at least two signatures are required on institutional bank accounts.

Care needs to be exercised, however, to avoid having too many people involved in approvals. Too large a number may result in the responsibility and authority of each becoming so diluted that approval system becomes a meaningless routine. A balance must be struck between the segregation requirement and the requirement for meaningful approval; that is part of the challenge of management. Segregating financial responsibilities can be difficult for agricultural research institutions which often operate with a small number of staff. In such cases, senior managers need to be closely involved in the process.

Preventing conflicts of interest is another basic principle of financial control. Conflict of interest, or even the appearance of it, can harm the reputation of a public institution such as a NARS. A conflict of interest arises when the institution or its personnel are not transacting at arm's length, that is, they are not conducting business on the basis of free-market competition with the objective of optimizing economic benefits to the institution. To prevent conflicts of interest, guidance should be provided to staff in the form of an institutional code of conduct and business ethics.

Several other measures should be taken to foster good financial internal control:

- Background documentation should be reviewed when financial transactions are being authorized or checks signed.
- There should be a clear paper trail for all transactions.
- Financial documents should be archived in secure areas.
- Monthly bank statements and checks should be carefully reviewed.
- Passwords should always be used to control access to computer systems containing financial records.
- Managers should ensure that all employees take the annual leave they are entitled to; this discourages employee-run fraud schemes since such operations tend to break down and be discovered when those responsible are away from work

Problems and solutions in financial control

A good system of internal controls demands good financial information. Concise, comprehensive, and timely reports giving details of financial activities should be periodically prepared and circulated to scientists and program managers. The frequency may vary according to local conditions, but monthly reporting is usually feasible with computerized systems.

Unfortunately, many countries don't have a comprehensive view of the resources being devoted to agricultural research within their borders. The units or projects within a NARS don't always report their financial results, either because they are not formal legal entities and therefore not obliged to do so, or else because they simply have no interest in financial reporting. Projects managed jointly with donors, for example, are generally not covered by the overall financial reporting system of the host research institute. "Few countries are consolidating all sources of funds and discussing total budgets when resource allocation is discussed" (Nestel and Gijsbers 1991).

The common theme of "national agricultural research" can be a good basis for consolidated financial reporting—for example, by a national agricultural research council or similar umbrella organization. Consolidated reporting, of course, doesn't require the various agricultural research entities to pool their funds. A consolidated report is simply a tool for getting an overview of the total agricultural research effort by a country and for evaluating the financial resources invested in that effort. In particular, it can provide a basis for comparing research institutions. In this respect, management information systems are a useful tool.

Controls exercised before financial transactions take place have been known to delay research operations and cause opportunities to be missed. Such financial controls should be minimal so as not to undermine operational effectiveness. There needs to be a balance between pre-transaction and post-transaction controls—one that will help prevent problems yet speed up the transaction process so that goals are achieved efficiently.

Osborne and Gaebler (1993) state that by carefully measuring results entrepreneurial organizations can minimize the need for rules. Measuring results in public-sector agricultural research institutions is, however, a complex and difficult undertaking. While the use of monitoring and evaluation systems can indeed minimize the need for rules, such systems depend on high-quality financial data such as those provided by budgeting and accounting systems.

Management controls are often designed around the financial structure. Agricultural research organizations operate with minimal staff, accounting services are frequently assigned responsibilities that have more to do with administration and logistics than with accounting. These activities are incompatible with the nature of accounting which is essentially an information and measuring function. Such supplementary activities may include procurement, inventories and stores management, vehicle fleet management, transport services, personnel services, general maintenance, and security.

While these are important activities, responsibility for them is sometimes assigned without regard to a basic principle of internal control, namely the segregation of responsibilities. This, in turn, weakens management control. NARS should therefore keep these administrative and logistical tasks separate from accounting. This will give the accounting function the necessary independence and credibility it needs to report objectively the financial information required for decision making and control.

In controlling financial resources, research managers sometimes have to deal with corruption. Public organizations such as NARS must be good citizens, respectful of local laws and customs. Corruption is often related to the procurement process in an organization; but it can be discouraged, or at least made more difficult, if several conditions are met:

- A truly competitive bidding process is used for procurement.
- The analysis of bids is based on factual information about costs and quality of performance.
- Suppliers or contractors are monitored carefully in the execution of procurement activities.
- A relatively independent body (purchasing committee) is set up to perform these tasks.

Tools for financial control

A variety of FM tools exists to help managers exercise financial control. Among them are

- approval and authorization of expenditures;
- financial reports resulting from the budgeting and accounting system;
- auditing and internal control checklists and questionnaires;
- financial analysis, financial ratios, and cost control.

Approval and authorization of expenditures should take place at a high level in the organization, and the people exercising this authority need to be clearly identified. In assigning responsibility and authority for approval and check-signing, consideration should be given to the principle of segregation of responsibilities and to the budgetary and responsibility centers in the institution. Scientists and program managers exercising check-signing authority should always request, review, and initial documents supporting a transaction.

Financial reports, presenting a financial overview of a NARS and institutional components, are necessary for planning. Monthly reports on financial activities per budget line item, and by research program or responsibility center, should be produced, analyzed, and used for control and evaluation of financial performance. Comparison of actual results with the budget often provides a first indication of operating problems or weaknesses.

Auditing is the examination of documentary (accounts, vouchers) and other evidences (systems and procedures, financial operations). It aims to determine the authenticity and fairness of registers and assertions and to evaluate financial performance and adherence to rules of conduct (policies, systems, and procedures) and contractual clauses. As a management control tool, it can be used for evaluation and improvement of operations (internal audit) and as an instrument of accountability to stakeholders (external audit).

Internal auditors work with institutional departments, divisions, and units to help them ensure they are following established institutional policies, systems, and procedures. When weaknesses are found, they propose corrective actions. An internal audit may also identify where and how improvements can be made in policies, systems, and procedures.

The role of the external audit is mainly to give an opinion as to the fairness of management's financial reporting to stakeholders. The external auditor is a third party to the process of financial accountability. When faced with weak financial management practices in an agricultural research institution, the external auditor's role becomes more focused on financial controls, on behalf of research managers and stakeholders.

Financial analysis is a useful tool for controlling financial resources and the costs of research programs, projects, and activities. Financial analysis refers to activities that involve examining costs-volume-revenue behavior. This includes the relative share of fixed versus variable costs, the cost-volume-revenue relationship of programs, projects, stations and laboratories and other cost-revenue centers. For example, in anticipating a reduction of 10% of the total budget appropriation, financial analysis might help research managers estimate the impact of such a reduction on the research programs of the institute. Financial analysis is often made using financial ratios.

Financial ratios have long been used to evaluate the performance of commercial businesses. They are used as indicators of profitability, liquidity, solvency, and efficiency. Some ratios really only apply to commercial operations, but others can be used for any organization, and are thus useful to NARS. The more frequently used ones are current ratio, quick ratio, inventory turnover ratio, sales or expenditures per staff/researcher. Table 3 lists indicators of financial health developed by the CGIAR Secretariat that could be used in NARS.

Financial ratios can be used to prepare reasonably accurate reports of actual financial performance. They must, of course, be compared against standards or averages and, in most cases, further analysis is needed to assess the significance for the institution. Nevertheless, they can be quick, easy-to-read indicators of progress, trouble spots, financial position, liquidity, and solvency. A pre-requisite to financial analysis using ratios is the existence of good-quality financial reports.

The calls for better performance measurement and **cost controls** are widespread. Agricultural research is a complex structure drawing together farmers, scientists, government agencies, and funding agencies. The current discourse is about cost cutting and the difficulties of demonstrating impact. Solutions will be easier to find if good accounting and cost-accounting system are in place, as we will see in the following section. But cost control is more than cost accounting and NARS research managers should consider the following cost factors when making agricultural research management decisions:

Table 3. Financial Health Indicators for NARS

Object	Description	Target
Long-term stability An indication of how long a NARS can survive financially if there is a delay in funding.	Capital fund plus operating fund divided by daily operating cost.	180 days of operation
Current ratio An indication that a NARS can pay its suppliers and that funds will not be used to pay old debts.	Current assets divided by current liabilities.	1.6
Working capital An indication that a NARS has funds to operate and support researchers' budgeted needs. It gives some assurance that grants and advances made can be used for immediate agricultural research needs.	Current assets - current liabilities divided by daily operating cost.	120 days of operation
Operating fund An indication of accumulated funds from self-financing. There should be a small surplus every year (4 to 5% of all income) to improve and consolidate the finances of a NARS.	Accumulated surplus divided by daily operating cost.	90 days of operation
Quick ratio An indication as to how quickly a NARS can pay its suppliers.	Cash plus cash equivalent divided by current liabilities.	1.0

- economies of scale and structure (volume purchases, stock levels, centralizing or decentralizing);
- savings that may result from accumulated institutional know-how and experience (scientific choices and relevant technologies);
- capacity utilization and institutional fixed costs;
- value chain or cost relationships between activities;
- sharing of institutional resources while carrying out activities;
- contracting out, make or buy decisions, using available internal assets and capabilities compared with using external resources;
- coordinating and timing activities to minimize costs (business cycle);
- costs of maintaining healthy social relationship with employees, suppliers, farmers, and other parties to the agricultural research process;
- geographical location and climatic characteristics;
- laws and governmental regulations and incentives (legal requirements).

Cost-benefit analyses and return-on-investment studies are used for planning and evaluation of performance. Although they are not easy to conduct and are often controversial, they can provide guidance in the control of financial resources. When planning or reviewing research programs, services, or products, a cost-benefit analysis may well reveal that performance, while acceptable to the clients and stakeholders, requires cost reductions. This information is important in the preparation of program and project funding requests.

The role of research leaders in financial control

In a NARS, financial control is the responsibility of the line managers (research scientists and program leaders), with advice and support from financial experts (controllers, budget officers, accountants, auditors, and financial consultants and analysts). Managers' performance on financial matters is critical to the institution, is under active scrutiny, and influences the behavior of others. Top managers in a NARS, including its board of trustees, also have a vital role to play in the financial control process. Control systems are ineffective unless personnel are convinced that top management is serious about them.

It must be clear, then, from the attitudes and behavior of agricultural research leaders that effective financial controls are a matter of high priority for them. They should show interest in day-to-day accounting and financial routines by making inquiries and observations. A well-phrased question from time to time is often more effective as a control technique than the use of formal procedures. Asking to be informed daily of the immediate cash situation and asking for monthly budgetary reports are excellent ways for NARS managers to show interest, exercise active financial control, and keep staff alert. Research leaders are major actors in the management control process which aims to motivate personnel to do certain things and refrain from doing others.

Financial controls: Summing up

The control of financial resources should not be looked upon strictly as an exercise in safeguarding money and assets. It is also a key task for achieving scientific objectives and improving the overall performance of agricultural research.

Recent trends in business place greater emphasis on management's responsibility to produce outputs and demonstrate outcome rather than on the responsibility to exercise day-to-day control over financial inputs. The best way to ensure that outputs are achieved without loss of financial control is to manage in such a way that individual interests are kept in step with those of the institution. The pursuit of such "goal congruence" puts research outcome first, while minimizing the need for strict rules of financial control.

The control of financial resources is thus a means rather than an end. It is an integral task of agricultural research management and a key element in maintaining the trust and goodwill of research investors. As such, it is vital to the performance and sustainability of a NARS.

Accounting

Process, concepts, principles

Accounting is a system for collecting, summarizing, analyzing, and reporting financial information about an organization. The accounting process is summarized in the following steps:

Bookkeeping

1. Record financial transactions (amounts) in journals.
2. Transfer amounts from journals to the general ledger (accounts). This is called posting.
3. Verify that the sum of all debits equals that of all credit balances (trial balance).

Accounting

4. Adjust calculations and trial balance.
5. Close noncumulative accounts.
6. Prepare financial statements.

Accounting and its end result, financial reporting, are based on several concepts from which accounting principles have been developed. The main accounting concepts are

- economic entity (e.g., a NARS);
- continuity or going concern (e.g., sustainability of a NARS);
- monetary unit (national currency);
- periodicity (time frame of activities, e.g., the agricultural research cycle).

These concepts underpin a set of conventions known as the Generally Accepted Accounting Principles (GAAPs), which, in turn, are the basis for recording and reporting financial transactions. The main accounting principles are

- conservatism in determining monetary values;
- consistency in accounting practices;
- matching income and expenses;
- cost and acquisition value of assets.

Financial reports, which are summaries of accounting information accompanied by statements of responsibility from management and the opinion of external auditors, generally include the following:

- the balance sheet, a report on the financial position of the economic entity at a given time;
- the statement of operations, a summary of revenues and expenditures over a period of time;
- the statement of changes in the financial position or statement of sources and application of funds, describing the flow (receipt and use) of financial resources over a period of time.

In NARS, accounting has to fulfill a variety of financial information needs and can thus be divided into three major types: budgetary accounting, financial accounting, and management accounting.

Budgetary accounting

This type of accounting serves the information needs of agricultural research managers and investors. It is a single-entry budget follow-up system aimed at strict control of funds. It responds to the formal legal and regulatory requirements of financing agreements, governments, and financing agencies, and to research managers' need to manage the research budget. It produces periodic reports on the execution of budgets and financing agreements.

Financial accounting

The objective of financial accounting, or general accounting, is to demonstrate the stewardship of financial resources. As such, it serves the needs of NARS stakeholders. Financial accounting responds to formal legal and regulatory accounting requirements (national and international) adapted to agricultural research activities. It produces reports that communicate the financial position, activities, and flows in a NARS for a given period (12 months), comparing these with the previous period.

Management accounting

The objective of management accounting (cost or analytical accounting) in agricultural research is to provide research managers with financial cost information, both current and historical, about research programs, projects, and activities. The information is used for planning and decision making (pricing research services). The cost-analysis reports produced by management accounting are customized to the managerial needs of scientists and program managers.

Accounting in NARS: Problems and solutions

Agricultural research management demands substantial knowledge and expertise in science, administration (i.e., general management), and finance. The last of these is an area in which NARS are generally recognized as being weak, and they should therefore take the necessary steps to build up their in-house accounting knowledge and expertise. Nickel (1989) states it well in his *Open Letter to a New Agricultural Research Director*: "We must make sure that the financial management of our institutions is in the most capable hands; and we need to become sufficiently familiar with financial matters in order to carry out this aspect of our management responsibilities effectively."

The modernization of accounting systems is sometimes accompanied by the belief that computer technology can fully compensate for weaknesses in financial knowledge and know-how. On the contrary, technology provides effective support only when there is already a base of knowledge, know-how, and good planning. In fact, the introduction of stand-alone computerized accounting systems into a knowledge vacuum can prove very costly.

Investors use financial reports to evaluate NARS results and management and to support decision making about funding. Weak financial reporting by a NARS can thus lead to difficulties in financing. If a NARS is not producing financial statements or its reports contain little relevant information, then the productivity of accounting efforts should be seriously examined. Good financial management will ensure that financial reports are suited to investors' needs and project a favorable image of the NARS and its work.

NARS, as public-sector organizations, face increasing demands to justify their use of resources. Meeting these demands is difficult for most NARS because they are subject to a traditional budgetary system (single-entry, government-type accounting) aimed at financial control rather than indicating what the funding is expected to achieve (Nestel and Gijsbers 1991). Traditional government-type accounting systems have been described as inadequate and "future blind" (Osborne and Gaebler 1993). This is a serious handicap. NARS should modernize their accounting operations and move toward the use of commercial-type accounting systems.

A standard reporting format for NARS would simplify the tasks of research managers and investors. The CGIAR has prepared guidelines for financial reporting by international agricultural research centers that might also prove useful to NARS. The following items are covered:

- a statement of financial position;
- a statement of activities;
- a statement of cash flow with supplementary information in the form of a schedule of grant revenue.

The CGIAR has also prepared model schedules for reporting funding, nongrant income, and fixed assets.

The CGIAR Annual Report shows expenditure levels on a worldwide basis for all centers. Such a model could well be useful at the national level in a NARS. An example of a financial report for a NARS is presented in Annex 2.

Accounting: Summing up

NARS can and should take several steps to ensure that accounting serves both their internal management needs and the external requirements of accountability. First, they should try to adopt a more commercial approach to accounting and to financial management in general. Second, research managers should become more familiar and involved with accounting procedures in their organization with a view to ensuring that budgetary, financial, and management accounting reports contain accurate and relevant information. Third, where accounting systems are nonexistent or nonfunctional, NARS should develop their own accounting policies, procedures, and practices in accordance with GAAPs, but adapted to the requirements of agricultural research. Finding out how other organizations handle accounting functions is a useful exercise. Last, accounting policies, methods, and procedures should be clearly recorded in a detailed accounting system manual, as well as in the organization's overall manual on institutional policies, systems, and procedures. Such documents should be made readily available to all staff with financial responsibilities.

A research organization's accounting system provides scientists and program managers with most of the historical and comparative financial data they need for planning, operational decision making, and the preparation of funding requests. In this sense, accounting is a critical tool both for good research management and for building the financial credibility needed to ensure a steady flow of resources from investors.

References

Nestel, B. and G. Gijsbers. 1991. An Overview of INFORM, an Information Management System. INFORM Guidelines 1 and 2. The Hague: ISNAR.

Nickel, J. L. 1989. *Research Management for Development: Open Letter to a New Agricultural Research Director.* Pp. 71-80. San José, Costa Rica: Instituto Interamericano de Cooperación para la Agricultura.

Osborne, D. and T. Gaebler. 1993. *Reinventing Government—How the Entrepreneurial Spirit is Transforming the Public Sector.* Reading, USA: Addison-Wesley P. C. Inc.

Recommended Reading

Anthony, R. N. and D. W. Young. 1994. *Management Control in Nonprofit Organizations.* Burr Ridge, Illinois, USA: Richard D. Irwin, Inc.

This book is intended for a course on management control problems in nonprofit organizations in general. It is not a book on accounting, but it provides insights into financial management tasks from a management control point of view.

CGIAR Secretariat. 1988 to 1995. Financial Guidelines Series and related documents. Washington DC: Secretariat of the Consultative Group on International Agricultural Research.

These are financial management guidelines for the international agricultural research centers supported by the CGIAR. Many of the guidelines are applicable to agricultural research institutions in general. Also papers prepared for general distribution in the context of re-engineering the CGIAR planning, budgeting, and funding systems describing a funding matrix that can be adapted to NARS.

ISNAR. 1993. Accountability—An Issue Here to Stay. Annual Report 1992, p. 11. The Hague: ISNAR.

This essay reviews the importance of institutional transparency and accountability and the need for research institutions to respond to this major concern of the decade.

Nestel, B. and G. Gijsbers. 1991. An Overview of INFORM, an Information Management System. INFORM Guidelines 1 and 2. The Hague: ISNAR.

This volume outlines an information management system developed by ISNAR and is aimed specifically at agricultural research managers. It provides insights into the importance and use of financial information in agricultural research institutions for programming and budgeting of research activities.

Nickel, J. L. 1989. *Research Management for Development: Open Letter to a New Agricultural Research Director*. San José, Costa Rica: Instituto Interamericano de Cooperación para la Agricultura.

This small book is a frank and lucid account of all aspects of agricultural research management. Chapter V is about budgeting and managing funds.

Osborne, D. and T. Gaebler. 1993. *Reinventing Government—How the Entrepreneurial Spirit is Transforming the Public Sector*. Reading, USA: Addison-Wesley P. C. Inc.

This publication is about introducing entrepreneurship into public- service institutions and increasing their efficiency. It emphasizes the need to change and the new approach to financial management in public institutions.

Menard, L. 1994. Dictionnaire de la comptabilité et de la gestion financière: anglais - français avec index français - anglais. Institut Canadien des Comptables Agréés; Ordre des experts comptables (France); Institut des réviseurs d'entreprises (Belgique). Toronto: ICCA.

It contains the definitions of more than 8,000 terms used in financial management. The definitions are based mainly on North American and European practices but are applicable internationally. The dictionary is English-French with a French-English index.

Based on contributions from a variety of partners in agricultural research, ISNAR prepared a collection of essays organized around the theme of financial management in agricultural research systems. They are available to research leaders on request, in the form of Discussion Papers.

1. A Strategy to Improve the Financial Management Function of a National Institute of Agricultural Research (NIAR). By David Holmes, Maryland, USA, and M. Ndiaga Dieng, Secretary General, ISRA, Senegal.
2. Budgeting in Time of Scarce Finance. By Philip Kok, Head Business Analysis and System Management, KIT, Amsterdam, The Netherlands.
3. Financial Management Systems for NARIs. By Jean-Claude Fayd'herbe, consultant, Harare, Zimbabwe.
4. Description of Key Accounting Processes and Reporting Requirements. By Adriaan Burger, Certified Registered Accountant, The Hague, The Netherlands.
5. Evaluating and Managing the Costs of Agricultural Research. By Jean-Louis Caminade, Chargé de mission, Secrétariat général, CIRAD, Paris.
6. The Use and Control of Scarce Financial Resources. By J. de Jong, Finance Department, DLO-NL, Wageningen, The Netherlands.
7. Internal Auditing. By H. Th. De Groot, Internal Auditor, NWO, The Hague, The Netherlands, and Ali Kissi, Inspector General, INRA, Morocco.
8. The Role of the External Auditor in a Not-for-Profit Organization. By Jeff Sluyter, Partner, Moret Ernst & Young, The Hague, The Netherlands.

World Wide Web Sites

http://www.financenet.gov	The worldwide home for public financial management, operated by the US National Science Foundation. For complete information on Financenet, send a blank Internet e-mail to: info@financenet.gov. Of particular interest is Financenet-L, on financial support of agricultural research and natural resource management.
http://www.cgiar.org/isnar/training/modules	ISNAR web site for training on agricultural research management. Financial management training modules for research managers are available in French and in English.
http://www.colybrand.com.au/fraud/index.htm	A few tips and tricks on preventing fraud.
http://www.gold.utsystem.edu/aud/othrsite.htm	Access to various internal auditing subjects and organizations.
http://www.ernie.ey.com/public/tour.htm	Access to professional consulting services on financial management.

Annex 1. Checklist for Soundness in Financial Management

Outside investors and other stakeholders want to be assured that a NARS or component research organization has a sound financial management system in place. Here are some of the questions they might ask:

Does the NARS produce an independently audited annual financial report?

Although a ministerial body or an autonomous research institute would report differently than a semiautonomous institute, a financial report should be available. Prepared and presented by the institute's management, this is an account of financial stewardship. It should be certified by an independent third party (i.e., an external auditor) as being a fair statement by top research management about the institution's financial situation and the use of entrusted or invested funds (see Annex 2 for an example of an annual financial report with accompanying management and auditor reports.).

Does the audit report certify sound management of financial resources?

The wording of the external auditor's opinion or comment is important. In most cases this will confirm that the financial reports presented by the NARS's management are a fair statement of the financial facts. In some cases, it may reveal that the auditor's work was incomplete for some reason, in which case the auditor will qualify the comment or state that the financial report is not a fair statement of financial facts (see Annex 2 for an example of an auditor's opinion).

Is the NARS spending too much or too little on the basis of spending per researcher?

Potential investors may look for an indication of spending per researcher in the annual financial report. This would allow for a comparison with other NARS based on available international statistics.

Is the NARS efficient in spending?

Investors would probably then want to know how much has been spent on a specific research programs and what has been achieved with that investment. An adaptation of the CGIAR financing matrix, part of the annual financial report of a NARS, would help answer those questions.

Is the NARS financially sustainable? Is it solvent?

Investors will look for some assurance that the funds provided are going to a financially healthy institution and are likely to be used for the purpose intended. A NARS under financial strain is more likely to respond to immediate financial demands than to agricultural research plans. Investors or donors may thus wish to examine indicators of financial health (see "Tools for financial control" in this chapter). Sometimes they are required to call on professional expertise to assess and minimize financial risks before making a funding decision. Indicators provided by the NARS may be useful in such an exercise.

Does the NARS have financial plans and strategies?

Have long-term research plans been translated into financial plans? Investors may want to examine the institute's financial profile to see the sources of funds. In that case, they may look for a published statement on financial plans and strategies. Answers may be found in the annual report in the form of a statement on research strategies.

Does the NARS have a budget that allocates available financial resources to activities?

Have research programs and priorities been set and have they been translated into an annual financial plan? The annual budget may have been presented at the annual general meeting of all research partners of the NARS.

Does the NARS use generally recognized business practices for purchasing and other expenditures (e.g., on travel), for financial control, and for accounting?

Investors may look at the organizational chart and ask: "From a finance point of view, how is this NARS structured? Is there an accountant in the house? If so, is that person qualified and part of the management team? Are researchers and research managers making use of and benefiting from the advice of good financial advisors?"

When it comes to financial management, does the NARS have a good reputation with its agricultural research partners?

To protect their own reputation, investors must take reasonable steps to ensure they are truly investing in agricultural research results and not wasting their money. They will inquire about the reputation of the NARS and its leadership as users and managers of public funds.

Can the NARS be trusted with "our" money or the "taxpayer's" money?

With positive answers to all the previous questions, the answer to this last one will probably be yes. Having assessed the financial management practices of the NARS, the investors will then make their recommendations or decisions about funding or contracts.

The above questions define the financial management challenge that NARS face in securing sustainable financing. Where does your institution stand? If, in responding to the questions, you identified some weaknesses in your institution by answering "No" or "Don't know," then you are not making full use of financial management practices to achieve research objectives and secure financing. You should therefore take appropriate remedial action.

Annex 2. Example of an Annual Financial Report for a NARO or NARS

Note: Italicized text indicates names and other information that need to be specified for the particular NARO or NARS submitting the report.

Contents

Report of Management Responsibility

To *the Investors* in the *National Agricultural Research Organization (NARO) of Country X*:

The accompanying financial statements of *the NARO of Country X* are the responsibility of management. They have been prepared on the basis of accounting practices prescribed or permitted by the national accounting plan and regulations of *Country X* and in accordance with generally accepted accounting principles. The financial statements of *the NARO of Country X* have been presented fairly and objectively in accordance with such principles.

The NARO of Country X has established and maintains a strong system of internal controls designed to provide reasonable assurance that assets are properly safeguarded and transactions are properly executed in accordance with management's authorization, and to carry out the ongoing responsibilities of management for reliable financial statements. In addition, *the NARO's* internal audit personnel provide a continuing review of the internal controls and operations of *the NARO* and the internal auditor regularly reports to the Audit Committee of *the NARO* Board of Trustees.

The financial statements of *the NARO* for the period ending December 31, *199Y* and *199X* have been audited by the independent accounting firm, *External Auditor Firm*. The independent auditors' report, which appears on the following page, expresses an independent opinion on the fairness of presentation of these financial statements.

The Audit Committee of *the NARO* Board of Trustees, consisting of trustees who are not officers of *the NARO*, meets regularly with management, representatives of the independent accounting firm, and internal auditing personnel to review matters relating to financial reporting, internal controls, and auditing. In addition to the annual audit of *the NARO* financial statements, auditors of the National Government of *Country X* and *other auditors* regularly examine the financial statements of *the NARO* as part of their mandatory examinations.

Chairperson, Board of Trustees

Director General

Principal Accounting Officer

Report of Independent Auditors

To *the Investors* in and Board of Trustees of *the National Agricultural* Research *Organization (NARO) of Country X*:

We have audited the accompanying consolidated statement of financial position of *the NARO of Country X*, a not-for-profit organization, and the related consolidated statement of financial activities and the consolidated statement of cash flows at December 31, *199Y*. These financial statements have been prepared in accordance with generally accepted accounting principles for not-for-profit organizations and the accounting policies set out in the accompanying notes. These financial statements are the responsibility of *the NARO's* management. Our responsibility is to express an opinion on these financial statements based on our audits.

We conducted our audits in accordance with international standards on auditing. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation. We believe that our audits provide a reasonable basis for our opinion.

In our opinion, the financial statements referred to above present fairly, in all material respects, the financial position of *the NARO* at December 31, *199Y*, the results of its financial activities, and its cash flows for the periods stated, in conformity with generally accepted accounting principles.

The data presented as supplementary information in *Exhibits XY* for *199X & 199Y*, although not a required part of the basic financial statements, have been audited and in our opinion are fairly stated in all material respects in relation to the basic financial statements.

External Auditor Firm

Date

City, Country

National Agricultural Research Organization of *Country X*

Consolidated Statement of Financial Position at December 31, 199Y

Monetary Unit 000's		199Y Actual		199X Previous
ASSETS				
Current Assets				
Cash and Cash Equivalents		4734		4205
Accounts Receivable		2117		1820
Donors	1125		975	
Employees	72		75	
Others	920		770	
Inventories		145		130
Prepaid Expenses		100		65
Other Current Assets		25		35
Total Current Assets		7121		6255
Fixed Assets				
Property, Plant and Equipment		9578		8748
Less: Accumulated Depreciation		7578		6703
Total Fixed Assets - Net		2000		2045
Total Assets		9121		8300
Liabilities and Fund Balances				
Current Liabilities				
Accounts Payable		3558		3466
Donors	2000		2000	
Employees	861		793	
Others	697		673	
In-Trust Accounts		200		200
Accruals and Provisions		325		315
Others		100		100
Total Current Liabilities		4183		4081
Long-Term Debt		0		0
Total Liabilities		4183		4081
Fund Balances				
Capital Invested in Fixed Assets:				
Capital Fund		2000		2045
Operating Fund		79		34
Other Funds		2859		2140
Total Fund Balances		4938		4219
Total Liabilities and Fund Balances		9121		8300

National Agricultural Research Organization of *Country X*

Consolidated Statement of Financial Activities at December 31, 199Y

Monetary Unit 000's	199Y Actual	199X Previous
Revenue		
Grants (Details Annexed if needed)	22649	20977
Other revenues	400	350
Total Revenue	23049	21327
Operating Expenses		
Research Programs	13263	12105
Conferences and Training	3806	3496
Information Services	2237	2132
Management and Administration	1762	1805
Other Operations	1262	1209
Total Operating Expenses	22330	20747
Excess (Deficit) of Revenue over Expenses	719	580

Allocated as Follows		
Operating Fund	719	580
Operating Expenses by Object of Expenditure		
Personnel Costs	15631	14523
Supplies and Services	3350	3112
Operational Travel	1563	1452
Others	911	785
Depreciation of Fixed Assets	875	875
Total Operating Expenses	22330	20747

N.B. The statement consolidates revenue and expenses by categories of research activities. A schedule (matrix) by activities and nature related to the institution could be annexed.

National Agricultural Research Organization of *Country X*

Consolidated Statement of Cash Flows at December 31, 199Y

Monetary Unit 000's	199Y Actual	199X Previous
Cash Flows from Operating Activites		
Excess (Deficit) of Revenue over Expenses	719	580
Adjustments:		
Depreciation	875	875
Decrease (Increase) in Assets:		
Accounts Receivable	-297	-155
Inventories	-15	-37
Prepaid Expenses	-35	20
Other Current Assets	10	-15
Increase (Decrease) in Liabilities:		
Accounts Payable	92	-42
In-Trust Accounts	0	100
Accruals and Provisions	10	-88
Net Cash Provided by Operations	1359	1238
Cash Flows from Investment Activities		
Acquisition of Fixed Assets	-830	-898
Cash Flows from Financing Activities		
Repayments of Long-Term Debt	0	0
Net Increase (Decrease)	529	340
Cash and Cash Equivalents		
Beginning of Year	4205	3865
End of Year	4734	4205
Net Increase (Decrease)	529	340

Part 4
Trends in Agricultural Research Funding

Steven R. Tabor

During the 1980s and early 1990s, developing-country agricultural research systems faced serious financial challenges. In Asia, funding and staffing continued to increase, but the rate of funding growth slowed down. In Africa and in Latin America, research systems were plagued by funding problems. Particularly in Africa, but also in Asia, the staff strength of research systems continued to expand faster than budgets. At the same time, the quality of the scientific labor force improved, with the numbers and proportions of trained scientists in agricultural research institutes continuing to rise.

Those years were also a time when national agricultural research systems were called on to do much more with few additional financial resources. In many countries, research mandates were broadened to give much greater attention to environmental sustainability. This required revamping or creation of new programs in the area of natural resources. Moreover, cutbacks in funding for international agricultural research programs meant that national programs had to develop the capacity to provide services previously in the international public domain.[1] The combination of a more extensive mandate, growing numbers of well-trained staff, and little budget growth raised difficult management challenges. Some countries responded by putting in place innovative mechanisms for mobilizing and managing agricultural research funding. The emphasis was on injecting a measure of competition into research financing and improving cost recovery. To reduce waste, more attention was accorded to priority setting, strategic thinking, and planning of research expenditures. In many countries, resources per scientist and real wages of scientific personnel declined.

The reasons for the spending slowdown vary and some countries have suffered more than others. Some of the larger countries that experienced persis-

[1]In constant terms, core funding of the Consultative Group on International Agricultural Research (CGIAR) rose from US$79 million in 1972, when there were four international centers, to US$238 million in 1993, when there were 18. In constant terms, core funding for the CGIAR centers fell by close to one-fifth during the period 1988 to 1994 and the number of international research personnel of the CGIAR organizations fell by one-third.

tent fiscal crisis, such as Nigeria, Mexico, and Brazil, have reported deep cuts in agricultural research expenditures. But fiscal circumstances alone don't explain all the changes in agricultural research spending. In several booming Asian economies, attempts have been made to shift more of the financing burden for agricultural research from the public to the private sector. In some countries, the slowdown in public spending clearly reflects a lack of public confidence in the ability of the research system to play a meaningful role in agricultural development. All three factors—fiscal capacity, the changing role of government, and loss of confidence—contributed to the spending slowdown.

Still, the sums of money allocated to agricultural research in the developing countries are considerable. For the early 1990s, estimated annual expenditures in the developing countries of Asia were about US$1.3 billion; in sub-Saharan Africa, $500 million; and in Latin America, $650 million. (See Table 1). Including estimates of $400 million for West Asia and North Africa and $350 million for international research, annual expenditures on agricultural research for and by developing countries were about $3 billion at the start of the 1990s.

Seeing these figures as a share of gross domestic product (GDP) helps put them into perspective. Africa allocated 0.3 percent of GDP to agricultural research, Asia 0.1 percent, and Latin America 0.05 percent. In the higher-income states of the Organiastion for Economic Co-operation and Development (OECD), the share of GDP was about 0.05 percent—the same as the Latin American average, but well below those of the African and Asian nations. In many low-income developing nations, the figure was in the range of 0.2 to 0.5 percent, implying that the poorer nations allocated 4 to 10 times more of their limited resources on agricultural research than did the higher-income countries.

In developing countries, governments provide most of the funding for agricultural research. Shares of overall public expenditures assigned to agricultural research indicate that most developing country governments accord a higher priority to agricultural research than do the higher-income OECD governments. Higher-income states allocated about 0.17 percent of public expenditures to agricultural research in the early 1990s, compared with 0.23 percent in Latin America, 0.6 percent in Asia, and 0.7 percent in Africa.

While the developing world allocated a bigger share of public expenditures to agricultural research, they also have many more farmers and a greater diversity of production conditions and constraints to address. The agricultural sector provides close to one-third of GDP in low-income nations, compared with about 3 percent of GDP in higher-income countries. Close to half of total employment is in agriculture in developing countries, while agriculture accounts for less than 5 percent of employment in higher-income nations.

While low-income developing nations accord a higher priority to agricultural research than do the higher-income nations, the sums of money involved are far greater in the latter. The Netherlands, a nation with about 150,000 farmers and where agriculture accounts for about 4 percent of GDP, annually spent slightly over $500 million (public and private contributions) on agricultural research in the mid-1990s—about the same amount committed to agricultural research by sub-Saharan Africa or Latin America in the early 1990s. In Japan alone, agricultural research expenditures (public and private) in 1993 were equivalent to $1.4 billion, or roughly equal to total spending on agricultural research in all of the low- and middle-income developing countries of Asia. The lesson from this is not that poor countries need to spend more on agricultural research, but that as national economies grow, the amount of resources that can be allocated to science and technology also grows.

Trends in agricultural research financing in Africa, Latin America, and Asia are discussed in Chapters 15 to 17. The differences between the three regions, and between countries in these regions, are significant. While certain patterns emerge, there is ample evidence that countries choose very different trajectories of agricultural research funding and staffing. In reviewing this evidence, it is worth bearing in mind that agricultural R&D expenditures are not defined consistently by all developing countries and that many countries do not regularly collect or report agricultural research outlays. Important efforts have been made to capture these trends, yet our understanding of R&D spending in these economies remains fragmentary.

Table 1a. Staffing and Funding of Agricultural Research in Sub-Saharan Africa

Country	Number of scientists	Total agricultural research expenditure (US$ millions)	Share of GDP to agricultural research (%)	Share of public expenditures to agricultural research (%)	Annual growth rate of real expenditures and of number of scientists (%)	
					Real expenditures (1981-91)	Number of scientists (1981-91)
	(1991)	(1991)	(1991)	(1991)		
Africa	9,000	500	0.3	0.7	-1.6	3.0
Botswana	54	7	0.2	0.4	-3.8	-0.2
Burkina Faso	142	9	0.3	1.6	9.5	2.8
Côte d'Ivoire	267	25	0.3	1.0	0.1	2.7
Ethiopia	387	17	0.3	0.8	10.6	9.6
Ghana	278	16	0.3	1.4	14.4	4.4
Kenya	819	33	0.5	1.6	4.0	4.8
Lesotho	28	1	0.1	0.2	-1.8	5.2
Madagascar	195	5	0.2	1.4	3.0	8.6
Malawi	185	12	0.6	2.6	2.4	3.2
Mauritius	106	5	0.2	0.9	1.3	3.8
Niger	102	5	0.2	1.3	3.9	6.6
Nigeria	1,012	24	0.1	0.2	-9.1	-0.3
Rwanda	57	4	0.2	1.1	11.4	9.5
Senegal	175	15	0.3	1.5	-4.3	-1.1
South Africa	1,339	122	0.1	0.5	1.8	1.3
Sudan	424	12	0.1	0.4	-5.5	2.3
Swaziland	20	2	0.3	0.8	-2.4	5.6
Tanzania	546	na	na	na	na	3.9
Togo	87	6	0.4	1.5	na	9.7
Zambia	20	15	1.5	3.0	-0.0	4.1
Zimbabwe	291	20	0.4	1.0	4.2	5.9

Note: Figures for Africa as a whole include an extrapolation for the 11 nations not included in the list above. Scientist numbers refer to researcher-equivalent personnel, which include an imputed portion of time allocated to research by university staff. Expenditure figures exclude outlays for long-term overseas training. Reported expenditures are estimated at the 1991 official exchange rate. Expenditure growth rates are in constant 1985 US dollars, converted at purchasing power parity exchange rates.

Sources: Pardey and Roseboom, Chapter 15; World Bank, *World Development Report*, 1993 and 1994; International Monetary Fund, *International Financial Statistics Yearbook*, 1993 and 1994.

Table 1b. Staffing and Funding of Agricultural Research in Developing Asia and Latin America

Country (year)	Number of scientists	Total agricultural research expenditure (US$ millions)	Share of GDP to agricultural research (%)	Share of public expenditures to agricultural research (%)	Annual growth rate of real expenditures and of number of scientists (%)	
					Real expenditures	Number of scientists
Asia	77,500	1,300	0.11	0.60	6.0	3.2
Bangladesh ('92)	1,650	20	0.10	0.66	3.7	3.1
China ('93)	60,000	358	0.09	0.54	5.0	6.2
India ('90)	4,830	426	0.15	0.66	7.5	1.7
Indonesia ('91)	2,100	61	0.06	0.29	6.2	4.2
Malaysia ('92)	870	93	0.16	0.57	3.6	1.8
Pakistan ('92)	3,650	53	.11	.41	4.8	3.6
Sri Lanka ('92)	470	8	.08	.29	-3.2	2.4
Thailand ('93)	na	220	.17	1.1	5.2	na
	1992-93	**1992-93**	**1992-93**	**1992-93**		
Latin America	7,500	650	0.05	0.23	-1.5	-1.5
Argentina	1,015	105	0.05	0.20	0.9	-0.3
Brazil	2,097	319	0.09	0.29	3.1	2.6
Bolivia	115	1	0.02	0.13	-1.3	2.3
Colombia	422	20	0.04	0.17	2.7	0.8
Ecuador	238	4	0.03	0.21	-6.1	2.3
El Salvador	99	1	0.02	0.14	-22.6	3.5
Guatemala	164	4	0.04	0.31	-1.3	1.5
Mexico	1,716	71	0.03	0.12	-7.3	0.0
Panama	124	5	0.08	0.30	2.5	5.5
Paraguay	112	3	0.05	0.35	-3.9	5.2
Peru	153	24	0.10	0.81	-0.7	-4.8
Uruguay	126	13	0.11	0.39	9.6	6.3
Venezuela	504	19	0.03	0.14	-2.4	2.4

Note: Figures for Asia as a whole and for Latin America as a whole include extrapolations for nations not included in the lists. Numbers of scientists and expenditure figures are for the main agricultural research organizations and do not include estimates of, for example, university research staff and their expenditures. Reported expenditures are the most recent estimates and are converted to US dollars at the official exchange rate. Expenditure growth rates are in constant 1985 US dollars, converted at purchasing power parity exchange rates.

Sources: Pardey, Roseboom, and Fan, Chapter 17; Echeverría, Trigo, and Byerlee, Chapter 16; World Bank, *World Development Report*, 1993 and 1994; International Monetary Fund, *International Financial Statistics Yearbook*, 1993 and 1994.

Chapter 15
Trends in Financing African Agricultural Research

Philip G. Pardey and Johannes Roseboom[1]

Introduction[2]

After significant increases in investments in public-sector agricultural research throughout much of sub-Saharan Africa in the 1960s and 1970s, the 1980s saw a reversal of this trend. Consequently, renewed attention is being paid to the policy options for public agricultural research in the region. To think through these options meaningfully requires a good grasp of the current state of agricultural research in Africa and some understanding of the history behind present policies and institutional arrangements.

The next section of this chapter briefly describes the institutional development of national agricultural research systems (NARS)[3] in sub-Saharan Africa (referred to as Africa hereafter). The third section gives a quantitative overview of the development of agricultural research personnel and expenditures over the past three decades, as well as measures of research spending intensities. Changes and differences in the cost structures of agricultural research are discussed in the fourth section, while the fifth focuses on funding sources and pays particular attention to the role of donor funding in Africa. The last section presents some conclusions.

Note: This chapter draws on the analysis component of the ISNAR-IFPRI Agricultural Science and Technology Indicators project. The authors wish to acknowledge DANIDA, SPAAR, and USAID for their contributions to this component.

[1]The authors thank Nienke Beintema for her very able assistance with the preparation of this chapter, as well as the reviewers for their comments on earlier drafts.

[2]Previous accounts of the development of African agricultural research are given by Lipton (1988), Lele, Kinsey, and Obeye (1989), Eicher (1990), Pardey, Roseboom, and Anderson (1991), and Pardey, Roseboom, and Beintema (1995).

[3]The concept of a NARS here covers all research focusing on crop, livestock, forestry, and fisheries production issues. The institutional coverage comprises government, semipublic, and academic research agencies operating at the national level. Supranational and private for-profit research agencies are not included.

Institutional Development

A brief history

With political independence in the late 1950s and early 1960s, most African countries inherited agricultural research structures that operated as part of a regionalized system. As the old colonial structures collapsed, many smaller countries found themselves effectively cut off from the network of research services to which they previously had direct access. Other countries were left with highly specialized research agencies that did not necessarily address local production problems. There were major disparities between countries with regard to research capacity. Moreover, research was largely oriented toward meeting the demands of export agriculture and paid little attention to the production constraints faced by subsistence farmers.

The post-independence transition followed different paths in the former British and French colonies (Eisemon, Davis, and Rathgeber 1985). Throughout much of anglophone Africa, the local agricultural research infrastructure and administrative control of it were ceded to the new governments as an integral part of the country's administrative structure. In many cases, the flow of financial and technical support for research from the UK to its former colonies contracted quite quickly, leaving the responsibility for financing and managing research facilities fully vested with the incoming governments.

In contrast, France continued to manage, execute, and fund agricultural research in most of her former colonies for many years following political independence. A series of bilateral agreements between France and the host governments was signed whereby research costs were shared. In most instances, France continued to provide scientists and cover related costs, while the host country provided support staff. These arrangements collapsed during the 1970s and 1980s as the governments of the independent states sought complete managerial control over the research agencies operating in their countries.

Size and structure

Over the past three decades, African NARS have grown substantially in size. In particular, the number of mid-sized systems (those employing 100 to 400 researchers) has increased. While in 1961 only four out of the 48 African NARS employed more than 100 researchers, by 1991 this number had grown to 22. Currently, only eight NARS in Africa employ less than 25 full-time-equivalent researchers, compared with 33 research systems three decades ago. While expansion has been the general rule, several research systems have collapsed or contracted sharply since independence because of political instability and civil war. Examples are the NARS of Angola, Mozambique, Uganda, Zaire, and, more recently, Liberia, Rwanda, and Somalia.

In most African countries, the rapid increase in resources committed to agricultural R&D in the initial, post-independence years went hand in hand with a proliferation of agricultural research agencies. This resulted in a rather fragmented institutional base for agricultural research. In contrast, the 1970s and 1980s were periods of consolidation during which various research entities were restructured into a single national agricultural research organization (NARO). By the early 1990s, public agricultural research in a large majority of African NARS (30 out of 48) was conducted by a single national agricultural research organization that employed more than half the country's agricultural researchers. However, there are no African countries in which the NARO is the sole provider of public agricultural research services. In particular, forestry, fisheries, and veterinary research tends to be conducted by agencies other than the NARO. In addition, commodity boards and universities conduct agricultural research alongside the NARO.

The institutional autonomy of the NAROs varies from country to country. Some operate at considerable administrative distance from the government bureaucracy (e.g., in Kenya and Uganda), while others are a department within a particular ministry (e.g., in Tanzania, Zambia, and Zimbabwe). Notably, the two largest African NARS, those of Nigeria and South Africa, have not adopted the NARO model, but continue to have relatively more fragmented research systems coordinated by a council.

University-based agricultural research has expanded markedly over the past three decades. The number of agricultural researchers at universities grew by more than 7 percent per annum between 1961 and 1991, and by 10 percent per annum if South Africa is excluded. As a result, the share of universities in agricultural research staff (measured in full-time equivalents) increased from 5 percent in 1961 to 10 percent in 1991. In 1961, only a few countries had the capacity to provide training in the agricultural sciences to the BSc level. Now, almost all African countries have some such capacity.

R&D Personnel and Expenditure Trends

Many African countries have made significant strides in the number of scientists working in their agricultural research agencies. In 1961, there were about 2,000 full-time-equivalent researchers, many of them expatriates, working in sub-Saharan Africa, including South Africa. By 1991, the number of researchers had grown to more than 9,000.[4] Most of these researchers are nationals (89 percent) and are reasonably well-qualified, with more than 60 percent trained to the postgraduate level.

For 19 countries, accounting for about two-thirds of the region's researchers, more complete time-series data are available (Table 1). Building from a rather small base, the number of scientists grew by 6.2 percent per annum

[4]This total includes 48 sub-Saharan African NARS. For 11 (usually small) national systems, an informed estimate, often involving extrapolations from secondary data or semiprocessed but incomplete survey data, was used to construct the 1961 and 1991 totals. These data exclude personnel working at or for international or regional agencies.

Table 1. Agricultural Research Staff and Expendituers

Country	Total number of researchers				Total expenditures				
	1961	1971	1981	1991	1961	1971	1981	1991	1991*
	(full-time equivalent researchers)				*(million 1985 international dollars)*[a]				
Botswana	1	16	47	54	0.18	2.67	10.84	9.82	6.8
Burkina Faso	10	25	91	142	1.61	2.85	7.11	19.13	9.1
Côte d'Ivoire	67	135	192	267	18.04	34.69	39.39	37.61	24.9
Ethiopia	14	66	153	387	1.90	9.19	21.14	40.53	16.5
Ghana	57	132	180	278	12.15	17.92	13.54	32.52	16.0
Kenya	121	326	484	819	22.36	49.69	62.28	95.97	33.3
Lesotho	1	7	17	28	0.25	1.85	3.78	3.60	0.7
Madagascar	70	114	95	195	17.89	29.28	11.45	15.63	4.6
Malawi	30	81	126	185	8.11	17.36	21.95	27.31	11.6
Mauritius	12	39	73	106	3.20	7.59	9.63	12.63	5.3
Niger	12	14	50	102	1.99	4.31	8.04	9.83	5.0
Nigeria	136	364	944	1,013	42.15	92.07	211.86	86.90	23.6
Rwanda	5	16	28	57	1.97	3.63	5.77	10.03	3.6
Senegal	60	71	184	175	17.82	25.48	37.36	23.85	14.6
South Africa	737	957	1,140	1,339	74.91	140.47	140.17	163.93	122.1
Sudan	48	125	324	424	12.99	34.94	39.90	21.46	na
Swaziland	6	12	5	20	1.05	2.87	3.53	5.89	2.4
Zambia	26	101	175	279	4.18	14.81	19.66	24.67	14.8
Zimbabwe	114	167	173	291	13.61	26.43	33.65	43.25	20.3
Total (19)	*1,525*	*2,769*	*4,481*	*6,159*	*256.37*	*518.10*	*701.03*	*684.55*	*335.2*

Note: Data cover all crop, livestock, forestry, and fisheries research conducted by government, semipublic and academic agencies. Expenditures include all salary, operating, and capital costs irrespective of the source of funding. Also included are the (international) salaries and related benefits of expatriate researchers. These expenditures are usually paid directly by donors and therefore not reported by the receiving agency. Other provisions in kind paid by the donors such as equipment and overseas training of nationals are not included.

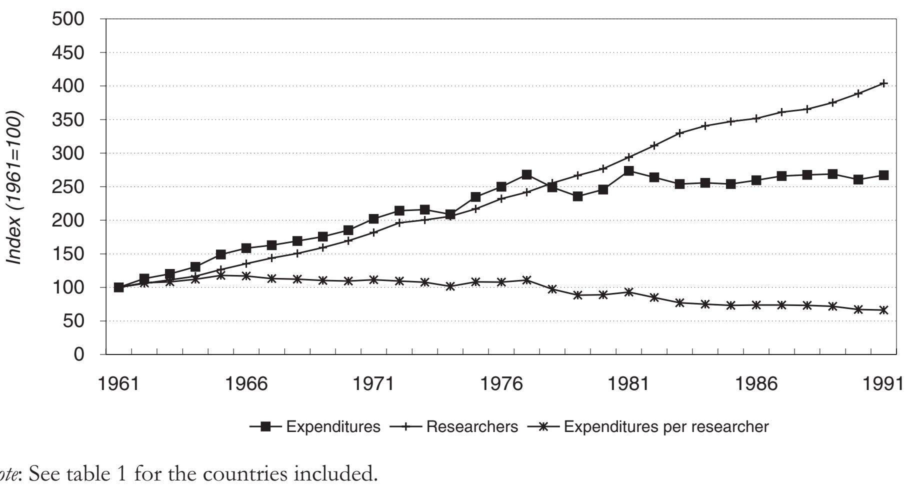
*In current million US$ at market exchange rate.

[a] To obtain an internationally comparable measure of the volume of resources used for research, research expenditures were compiled in local currency units, then deflated to base year 1985 with a local GDP deflator (World Bank 1995), and finally converted to 1985 international dollars using 1985 purchasing power parity indexes (PPPs) (Summers and Heston 1991). PPPs are synthetic exchange rates that are designed to reflect the purchasing power of currencies.

throughout the 1960s and by 4.9 percent during the 1970s. Growth slowed further to an average of 2.8 percent in the 1980s. These averages mask a good deal of cross-country variation. The numbers of agricultural research staff in Ethiopia, Madagascar, and Rwanda grew by 8 to 10 percent annually during the 1980s, while in Botswana, Nigeria, and Senegal there was little if any growth during this period.

Real agricultural research expenditures grew rapidly (6.8 percent per annum) during the 1960s, moderately (2.6 percent) during the 1970s, and ceased to grow throughout the 1980s and early 1990s for the 19-country sample reported in Table 1. But again, the more detailed data reveal a substantial degree of volatility and cross-country variation around this trend. The rate of growth in research spending during the 1980s ranged from -9 percent per annum for Nigeria to over 14 percent for Ghana. The pattern of growth in Nigeria's agricultural research expenditures was particularly volatile. After substantial growth during the 1960s and 1970s, largely financed by revenues from a booming oil sector, Nigeria's agricultural research expenditures contracted sharply during the 1980s. They are currently less than half the level that prevailed during the late 1970s.

The overall pattern of growth of research expenditures is in stark contrast with the growth of research personnel. The number of research personnel and the amount of resources committed to research developed largely in parallel from 1961 to 1981, but thereafter followed dramatically different paths (Figure 1). Real expenditures stalled after 1981 while the number of researchers continued to climb. As a result, the quantity of resources per researcher in 1991 for this group of 19 countries has declined by about 30 percent, compared with the corresponding 1981 figure. Burkina Faso and Ghana are the only two countries



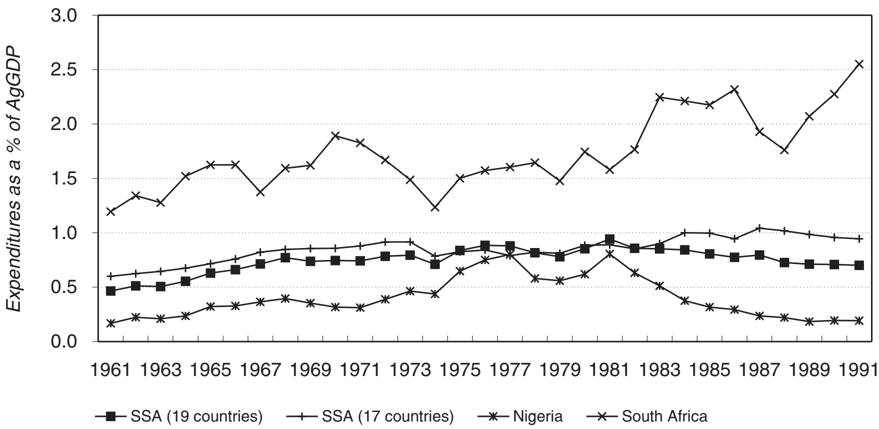
Note: See table 1 for the countries included.

Figure 1. Research expenditures, research staff, and spending per researcher

in this group where the resources provided to a researcher were greater in 1991 than in 1981.

Research spending intensities

Figure 2 provides an overview of the long-term development of the agricultural gross domestic product (AgGDP) research intensity ratio (agricultural research expressed as a proportion of AgGDP spent on agricultural research). The 19-country average increased throughout the 1960s and much of the 1970s, but then declined steadily from a peak in 1981 of 0.93 percent to 0.69 percent by 1991—below the level of intensity that prevailed 20 years earlier.



Note: See table 1 for the countries included in the 19 country sample.

Figure 2. Expenditures as a percentage of AgGDP, 1961-91

The average for this sample of countries masks some major differences in research intensities among Nigeria, South Africa, and the rest of Africa. South Africa's research intensity ratio has trended upward for much of the post-1961 period. At 2.6 percent in 1991, it is significantly higher than most other countries in the region and in line with the public research intensities reported for many developed countries. The year-to-year fluctuation of the ratio evident from Figure 2 reflects weather-induced changes in agricultural output rather than any significant year-to-year variation in research spending.

In contrast to the persistent upward trend of South Africa's research intensity ratio, Nigeria's grew steadily throughout the 1960s and early 1970s but declined precipitously from 0.81 percent in 1981 to a lowly 0.19 percent in 1991. In 1991, the 17-country African average (excluding Nigeria and South Africa) was 0.92 percent, compared with 0.69 percent for the 19-country sample that includes these systems.

Government spending intensities

An alternative perspective is obtained by expressing public agricultural research spending as a percentage of total government expenditures. This is done in Table 2. Data for Nigeria and South Africa have been reported separately and they have been excluded from the respective middle- and high-income classes whose averages they would dominate.

Table 2. Research Expenditures as a Percentage of Government Expenditures in Africa

Category	**1971**	**1981**	**1991**
		(percentage)	
Low income (7)	1.14	0.88	1.14
Middle income (5)	1.91	1.16	1.13
High income (4)	1.57	1.16	0.58
Subtotal (16)	1.57	1.06	1.06
Nigeria	1.50	0.84	0.27
South Africa	0.59	0.44	0.42
Total	*0.97*	*0.76*	*0.60*

Note: Income classes were defined as follows: low, less than \$750; middle, \$750-1,500; and high, more than \$1,500 of 1991 per capita income measured in 1985 international dollars. The countries included here are the same as those in Table 1 except for Sudan because of incomplete government expenditure data.

Whereas the conventional research intensity ratio (i.e., agricultural research spending as a share of AgGDP) for South Africa has been rising and has consistently been among the highest for all African countries since 1961, agricultural research expenditures have constituted a falling and relatively small share of total government spending. In 1991, agricultural research in South Africa accounted for only 0.42 percent of total government spending (compared with 0.59 percent in 1971). This contrasts with the 16-country average presented in Table 2 which was about 2.5 times higher. Aside from the exceptional case of Nigeria, poorer African countries currently commit much more of their public-sector resources to agricultural research than Africa's richer countries. However, with the exception of the low income countries, governments in poorer and richer African countries alike were giving less priority to agricultural research spending in 1991 than 1971.

Cost Structures

The dramatic drop in expenditures per researcher since 1981 as shown in Figure 1 is due to several factors. Aside from the obvious asymmetries between the growth in total spending and the growth in the number of researchers supported by those expenditures, there have been some quite important changes over time in the composition of the personnel and expenditures aggregates.

With regard to the research staff, for example, there has been a widespread move to replace relatively expensive expatriate researchers with less costly national researchers. About 12 percent of the reduction in spending per researcher between 1981 and 1991 can be attributed to the declining dependency on expatriates. If Nigeria and South Africa are excluded (both of which by 1981 already employed comparatively few expatriate researchers), as much as 36 percent of the reduction can be attributed to a shift from expatriate to local researchers. Working in the opposite direction was the considerable upgrading of the degree status of local researchers, although the additional salary costs resulting from this development are modest compared with the savings from having fewer expatriates.

Other factors strongly affecting spending per researcher are the size and composition of the support staff. African agricultural research organizations employ an average of nearly 10 support staff per researcher, which is high even in a developing-country context. Although some organizations have sought to shed excess support staff in recent years (often as part of a government-wide reduction of staff), this tendency has been far from universal. The overall picture that emerges is that many agricultural research organizations struggle with overstaffing at the same time they are having difficulty finding suitably qualified staff to fill critical technical and managerial positions.

Similar and clearly related issues are reflected in the cost structures that underlie the expenditure aggregates. Research systems that undergo major programs of capital investment are likely to have higher spending-per-researcher than those that simply maintain existing physical infrastructure. Although no comprehensive cost-share data for the earlier years are available, fairly adequate data do exist for the post-1985 period. These data suggest that the shares of personnel, operating, and capital expenses in total research costs were reasonably stable throughout this period, although real spending per researcher, at least in the aggregate, declined (Table 3).

The stability in these overall cost shares belies dramatic institutional differences in underlying cost structures. Table 3 reports comparable cost components for a group of eight research agencies operated by commodity boards. Compared with the average for all agricultural research agencies, these agencies commit, on average, nearly double the amount of resources per researcher. Moreover, this high level of spending persists across the personnel, operating, and capital cost components. The relatively high expenditures per researcher may be partly due to the fact that commodity-board research agencies commonly operate agricultural holdings substantially larger than strictly necessary for the research they conduct. Although these large holdings generate income, they also require additional support staff, agricultural inputs, machinery, etc., which adds to total expenditures. Netting out these "nonresearch" expenditures is quite difficult as the research and production activities are often integrated.

Table 3. Expenditures per Researcher Broken Down by Cost Category

	All agricultural research agencies			
Cost category	**1986**	**1991**	**1986**	**1991**
	(1985 international dollars)		*(percentage share)*	
Personnel	76,000	68,000	58.8	60.4
Operating	36,000	29,000	28.1	25.6
Capital	17,000	16,000	13.1	14.0
Total	*130,000*	*113,000*	*100*	*100*

	Commodity-based research agency			
	1986	1991	1986	1991
	(1985 international dollars)		*(percentage share)*	
Personnel	130,000	103,000	52.2	50.4
Operating	83,000	72,000	33.3	35.0
Capital	36,000	30,000	14.4	14.6
Total	*249,000*	*204,000*	*100*	*100*

Note: Based on data from the following 17 countries: Burkina Faso, Cape Verde, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mali, Mauritius, Niger, Nigeria, Rwanda, Senegal, South Africa, Togo, and Zimbabwe. The personnel cost data represent the salaries and benefits received by both national and expatriate researchers, plus the personnel costs of all technical, administrative, and other support staff scaled by the number of full-time-equivalent researchers.

The decline in personnel costs per researcher shown in Table 3 reflects a shift from expatriate to local researchers as well as a decline in the real salaries and benefits paid to African researchers and their support staff. This parallels a more general decline in the purchasing power of government salaries throughout Africa during the past two decades (Robinson 1990)—a decline that has caused the living standards of many government employees to fall below a reasonable level. In addition, some African governments have had difficulty paying salaries on time. This has resulted in widespread absenteeism in many research agencies as staff take up other additional jobs to make ends meet. Research managers face a dilemma in attempting to deal with these issues. Freeing up resources by reducing staff is often made difficult by public-service regulations. Likewise, the same regulations make it difficult to raise the salaries of staff above the public-service salary structure.

For an alternative look at spending-per-researcher, Table 4 presents the 1991 data in current U.S. dollars. Comparative cost calculations based on official market exchange rates may be more familiar to those who actually fund research. A noteworthy feature of these data is the large share of expenditures per researcher due to technical assistance costs. For nine out of the 17 countries listed in Table 4, the amount spent on the salaries of expatriate researchers exceeds that spent on local staff. But NARS managers cannot do much about this as technical assistance costs are generally incurred by donors and there is little fungibility between local and expatriate expenses.

Table 4. Expenditures per Researcher by Cost Category in US Dollars (1991)

	Personnel costs[a]					
Country	**Local**	**TA[b]**	**Total**	**Operating**	**Capital**	**Total**
			(current U.S. dollars per researcher)			
Burkina Faso	21,469	33,117	54,586	22,074	22,056	98,716
Cape Verde	36,560	41,379	77,939	30,330	4,678	112,947
Côte d'Ivoire	35,878	56,471	92,349	25,316	2,707	120,372
Ethiopia	16,171	8,586	24,757	10,530	10,088	45,374
Ghana	25,074	10,185	35,259	9,859	22,813	67,930
Kenya	19,118	12,660	31,778	10,771	6,772	49,320
Madagascar	11,727	25,140	36,866	8,680	2,664	48,210
Malawi	20,054	22,599	42,653	19,133	7,477	69,262
Mali	14,676	16,190	30,866	12,173	8,812	51,851
Mauritius	35,307	0	35,307	25,737	9,298	70,341
Niger	34,134	27,273	61,407	3,920	1,615	66,942
Nigeria	9,748	1,812	11,560	5,477	4,490	21,527
Rwanda	28,813	36,735	65,547	17,072	4,533	87,152
Senegal	34,484	45,031	79,515	17,965	3,498	100,978
South Africa	66,088	0	66,088	18,929	6,133	91,150
Togo	20,753	30,000	50,753	15,079	6,115	71,946
Zimbabwe	34,610	16,744	51,355	15,791	9,281	76,426
Weighted average	*30,026*	*12,760*	42,786	*13,505*	*7,087*	*63,377*

[a] Represents all personnel related costs (including salaries and benefits of *all* staff) divided by the number of researchers.
[b] TA = technical assistance.

Funding Perspectives

Institutional differences

Based on a sample of 13 African countries, government funding was the most important source of support for national agricultural research in 1991, although direct support from international donor agencies was of almost equal importance (Table 5). In fact, for eight of the 13 countries, donors provided more funding than all other sources combined. Our data indicate that the smaller and poorer countries currently rely more heavily on donor support than the larger and comparatively richer African countries. Moreover, between 1986 and 1991 the relative importance of donors as a source of funding for agricultural research increased significantly, while that of governments declined.

Table 5. Funding Sources

Source of funding	All agricultural research agencies 1986	All agricultural research agencies 1991	Commodity-based research agencies 1986	Commodity-based research agencies 1991
	(percentage share)		*(percentage share)*	
Government	55.9	47.5	11.3	4.4
Own income	6.5	4.9	32.1	17.6
Specific taxes	2.3	4.2	50.0	69.6
Donor	34.0	42.7	3.9	7.3
Other	1.4	0.8	2.8	1.1
Total	*100*	*100*	*100*	*100*

The funding profile of research agencies managed by commodity boards is quite different from other publicly managed agricultural research agencies (Table 5). The commodity-board research agencies rely on commodity taxes and their own earnings as their principal sources of funding. However, in keeping with overall trends, government support to commodity-board research agencies declined in relative as well as absolute terms between 1986 and 1991, while donor support increased.

Although industry funding of agricultural research was quite common during the colonial period, this has all but disappeared in more recent times. The contraction of industry support in most instances coincided with the consolidation of agricultural research into national agricultural research organizations during the 1970s and 1980s. These new organizations were bound by public-service regulations and often lacked the administrative flexibility to deal with commodity-specific funding arrangements. For its part, industry had little incentive to channel some of its earnings to agricultural research conducted by agencies over which they had little control or influence.

Donor funding

Contributions by external donors to African agricultural research grew markedly during the late 1980s. For the 13 countries covered by Table 5, donor contributions climbed by 28 percent from \$116.4 million (1985 international dollars) in 1986 to \$148.7 million in 1991—an increase from 34 percent to 43 percent in the donor share of total agricultural research spending. This growth in donor funds more than offset the 14 percent decline in government support for research for this group of countries during the same period. In only four of the 13 NARS did donor funding decline.

Donor support for agricultural research increased despite a stagnation in overall donor funds directed to Africa and a contraction in donor support to developing countries more generally (OECD 1992). This may be due in part to a shift in the World Bank's sectoral assistance to agriculture—toward research and extension and away from support to publicly managed marketing boards and cooperatives.

During the 1980s, the World Bank funded agricultural research projects in 18 African countries. Support to research was channeled through either "free-standing" projects or components of broader projects. Funding for these was usually a mix of soft loans and grants, with about 37 percent of the money provided by the World Bank, 35 percent by other multilateral and bilateral donors, and 28 percent by national and local government sources. The accumulated value of the agricultural research projects in Africa approved by the World Bank between 1981 and 1991 was slightly more than $1 billion (in nominal terms). The largest of the free-standing research projects involved $204 million for Kenya's National Agricultural Research Project, the smallest $13 million for research in Guinea. The value of the component research projects ranged from $300,000 (Haute Bassins Agriculture, Burkina Faso) to $12 million (Rubber IV, Côte d'Ivoire) (World Bank 1996).

Many African economies remain fragile and the demands placed on the public sector in these countries are heavy. It is therefore likely that donor support for research, in some cases substantial, will continue to be necessary for some time to come. However, it is questionable whether high levels of support can be sustained indefinitely. Serious thought should be given to the appropriate amount to spend on R&D and to the design of funding mechanisms. In particular, donor resources need to be disbursed in such a way that they avoid crowding out domestic sources of support (which may well have happened over the past few years at least). There is also a need to develop means of mobilizing and deploying funds that stimulate rather than dissipate the productive potential of these resources.

Compared with other developing countries, African countries tend to invest a relatively high percentage of their AgGDP in agricultural research. In 1991, the developing-country average was about 0.5 percent, against Africa's 0.7 percent. To a large extent, Africa's comparatively high research intensity ratio reflects the sizable amount of donor funding channeled to agricultural research.

Figure 3 presents 1991 research intensity ratios for 23 countries, by source of funding (donor and national). If all sources of funds are included, the intensity ratio ranges from 0.2 to 6 percent. If research spending intensities are expressed in terms of spending by research agencies from domestic sources only (i.e., net of international loan and grant funds), the picture changes considerably. First, the average spending intensity is lowered by one-third, from 0.7 percent to 0.5 percent. Second, the ranking of countries changes considerably. Botswana invests its own funds more intensively in agricultural research than any other country in the sample. A relatively large and quite prosperous nonagricultural sector forms the basis for this government support. At the other end of the spectrum, Burkina Faso, Nigeria, Rwanda, and Sudan spend less than 0.2 percent of their AgGDP on agricultural research using local funds.

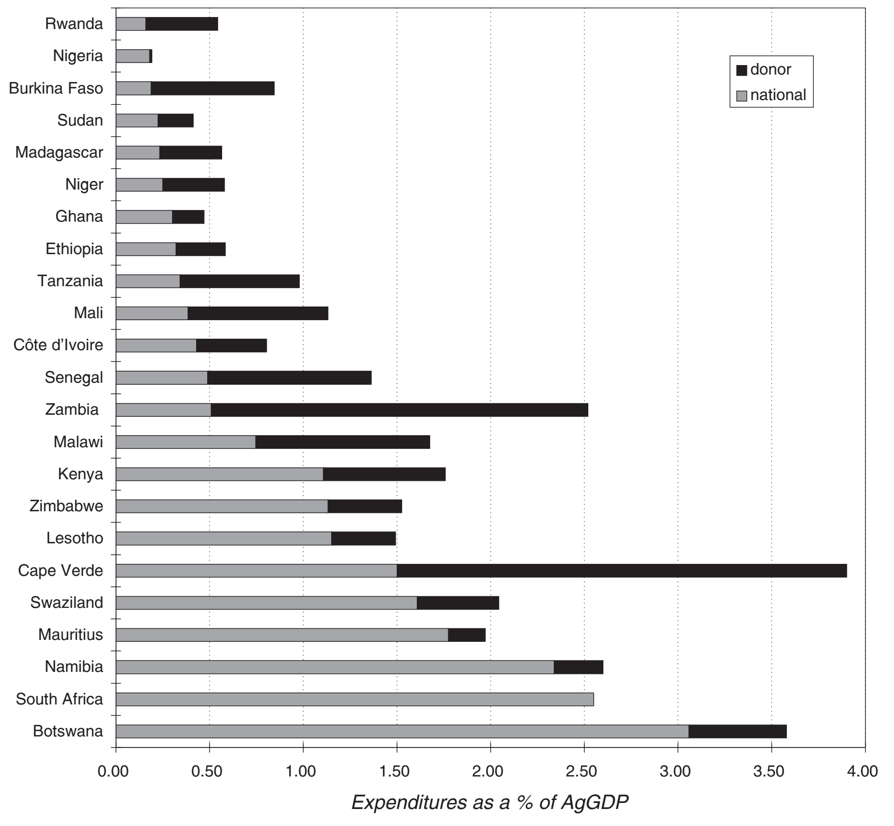


Figure 3. Research expenditures by funding source, as a percentage of AgGDP, 1991

Conclusion

Sub-Saharan African countries have made progress in developing their agricultural research systems over the past three decades. In particular, the development of research staff has been impressive. First, there has been a sixfold increase in the number of researchers (if South Africa is excluded). Second, reliance on expatriate researchers has declined from roughly 90 percent expatriates in 1961 to 11 percent in 1991. Third, education levels have improved, with more than 60 percent of the researchers holding a postgraduate degree in 1991. Finally, the indigenous capacity to train researchers has expanded, although at the MSc and PhD levels this is still limited.

Developments in agricultural research expenditures were considerably less positive. After reasonable growth during the 1960s and early 1970s, growth in expenditures basically stopped in the late 1970s. Although there is considerable variation between countries, this trend highlights the notion that many African countries have lost ground in their efforts to finance agricultural research.

Donor support has clearly increased in importance. Its share in the financing of agricultural research increased from 34 percent in 1986 to 43 percent in 1991. While the increased outside support somewhat compensated for declining government funding, it is unlikely that such high levels of support can continue indefinitely.

Many of the developments of the past decade in personnel, expenditures, and sources of support for public-sector R&D in Africa are clearly not sustainable. Richer and poorer African countries alike are giving lower priority to spending on agricultural research today than they did two decades ago. In addition, the rapid buildup of research staff is not paralleled by an equal growth in financial resources. Spending per researcher declined dramatically during the 1980s. Resources are spread increasingly thin over a growing group of researchers, negatively affecting the efficiency and effectiveness of agricultural research. In addition, the erosion of the purchasing power of salaries has seriously affected staff morale.

To tackle this complex set of related problems, a major effort is needed by all parties involved: research managers, national policymakers, and donors. Both governments and donors need to arrive at a realistic framework for financing within which national agricultural research agencies can operate. It is rather unlikely that in the current situation of fiscal austerity government support for agricultural research will increase significantly. In some countries, it will be quite an achievement just to stop further declines in government support. The increased dependency on external donor funding is also a reason for concern, as it is only a temporary solution to funding problems. The need to explore opportunities for obtaining funds from additional *national* sources thus takes on increasing importance.

References

Eicher, C. K. 1990. Building African Scientific Capacity for Agricultural Development. *Agricultural Economics* 4(2):117-143.

Eisemon, T. O., C. H. Davis, and E. M. Rathgeber. 1985. Transplantation of Science to Anglophone and Francophone Africa. *Science and Public Policy* 12(4): 191-202.

Lele, U. J., B. H. Kinsey, and A. O. Obeya. Building Agricultural Research Capacity in Africa: Policy Lessons for the MADIA Countries. Paper prepared for the joint TAC/CGIAR Centers Directors Meeting, Rome, Italy, June 1989.

Lipton, M. L. 1988. The Place of Agricultural Research in the Development of Sub-Saharan Africa. *World Development* 16:1231-1257.

OECD. 1992. *Development Co-operation*. Paris: Organization for Economic Cooperation and Development.

Pardey, P. G., J. Roseboom, and J. R. Anderson. 1991. Regional Perspectives on National Agricultural Research. In *Agricultural Research Policy: International Quantitative Perspectives*. Eds. P. G. Pardey, J. Roseboom, and J. R. Anderson. Cambridge, UK: Cambridge University Press.

Pardey, P. G., J. Roseboom, and N. K. Beintema. 1995. African Agricultural Research: Three Decades of Development. ISNAR Briefing Paper No. 19. The Hague: ISNAR.

Robinson, D. 1990. Civil Service Pay in Africa. Geneva: International Labor Office.

Summers, R., and A. Heston. The Penn World Table (Mark 5): An Expanded Set of International Comparisons, 1950-1988. *The Quarterly Journal of Economics* (May 1991): pp. 1-41

World Bank. World Tables. Various printed and electronic editions, 1995 and other years. Washington, DC: World Bank.

World Bank. 1996. Achievements and Problems in Development of National Agricultural Research Systems. Report No. 15828. Washington, DC: Operations Evaluation Department, World Bank.

Chapter 16
Financing Agricultural Research in Latin America

Ruben G. Echeverría, Eduardo J. Trigo, and Derek Byerlee

Introduction

Investments in agricultural research in Latin America and the Caribbean (LAC) have been shown to have high payoffs and they play a vital role in rural-income generation and natural resource conservation. Yet, overall funding for national agricultural research institutes in the LAC region has decreased in real terms since the early 1980s even though the number of scientists has grown. Chronic underfunding now threatens the operating efficiency, effectiveness, and even the survival of several research systems in the region. Solving this financial challenge is currently the major concern of these NARS and, therefore, central to the agenda of policy makers and development assistance agencies, both multilateral and bilateral.

Agricultural research can, in this financial context, be usefully examined from several angles, including source of funds, the type of institution executing the research, and the level at which the research is conducted (subnational, national, regional, or international). This chapter focuses on the national level, emphasizing alternative funding sources and options for executing research. A national agricultural research system, or NARS, is here defined to include public-sector research institutes, universities, nonprofit organizations, producer groups, and private companies that engage in agricultural research.

The chapter reviews several innovative funding mechanisms: commercialization of research results through joint public/private-sector ventures; competitive funds; research foundations; farmer-managed levies on agricultural production; and greater involvement of universities and private agribusiness. All these arrangements are in use and are helping to alleviate severe budgets constraints on Latin American NARS. However, it is imperative that public funding be increased to address new demands on the NARS (for example, natural resource management) and to fill growing gaps in the development and maintenance of the capital infrastructure, both physical and human, for research. To ensure that agricultural research is an attractive investment for governments, as well as for farmers and the private sector, reforms in the traditional national research institute model are needed.

NARS in the 1990s: Economic and Institutional Environment

Policy reforms and the enlarged agricultural research agenda

Agricultural growth is a catalyst for broad-based economic growth in low- and middle-income economies. In most LAC countries, agriculture is a major source of income, employment, and export earnings, and thus critical to alleviating rural poverty and safeguarding natural resources. During the past 10 to 15 years, most LAC countries have introduced monetary and fiscal policy reforms, reduced the role of government, promoted private-sector investment, and introduced sector-specific reforms aimed at stimulating growth. These reforms have sharply altered the economic context for agricultural development.

Policy reforms, market liberalization, a reinvigorated private sector, and the concern for the environment have all placed new demands on the research agenda of the region's NARS. With a growing emphasis on free trade, improved technology is important in countries' efforts to stake out their comparative and competitive advantages. In particular, comparative advantage (traditionally based on natural resources) will increasingly depend on investment in knowledge and human capital. Also, the product mix in the agricultural sector is subject to rapid changes through trade. NARS must be positioned not only to promote change but also to react quickly to change.

NARS are being called upon to give greater attention to postharvest issues (Cap and Trigo 1995), poverty alleviation, environmental protection, and resource management. At the same time, agricultural technologies are becoming more management intensive, partly because improved information (e.g., integrated pest management principles) can now substitute for environmentally harmful chemicals, and partly because of demands on all sectors of society to reduce costs and increase international competitiveness. This new management intensity, in unison with the expanded research agenda, places enormous demands on research systems to supply farmers and agribusiness with more and better technical information.

Finally, the technology used in agricultural research is itself changing, resulting in a shift in the production functions of research. Advances in molecular biology and information technology have opened new avenues, allowing researchers to cut costs by increasing the temporal and spatial efficiency of technology development and testing. However, these same technologies call for substantial initial investments in human and physical capacity. In addition, given the global trend to privatize knowledge, developing countries must invest more in traditional basic sciences ("pre-technology science") as a prerequisite for technology generation.

The decline in public funding for agricultural research

The new demands on NARS have coincided with sharp declines in agricultural research investment in a number of LAC countries. As a rough estimate, research budgets among the region's national agricultural research institutes (or "INIAs" to use the Spanish acronym) dropped, on average, by about 15 percent between the early 1980s and the early 1990s, while the number of personnel increased by more than 20 percent.[1] With only a few exceptions, this resulted in lower expenditures per researcher (Table 1), smaller operating budgets, and reduced real salaries for scientists, with negative implications for performance.

Private-sector investment in agricultural research in the region has increased but still accounts for less than 15 percent of total resources invested. Measured as a share of agricultural GDP, overall research intensity is about 0.5 percent in the LAC region. Despite the low level of investment, this figure still represents a significant effort because of the relatively large size of the agricultural sector in the overall economy (compared with more developed countries) and the weak tax base of most countries in the region (Elliott 1995).

Agricultural research in the LAC region is still largely in the public sector. Table 2 presents estimates of research expenditures by public institutes, universities, producer groups, and private companies in eight countries that represent more than 90 percent of the region's total research expenditure. Although

Table 1. Estimated Evolution of Public Agricultural Research Investments, 1981-1992

		Number of researchers			
Country	**Institute**	**1981**	**1986**	**1991**	**1992**
Argentina	INTA	1,045	1,028	955	1,051
Bolivia	IBTA	89	82	115	115
Brazil	EMBRAPA	1,576	1,724	2,105	2,097
Chile	INIA	169	196	207	189
Colombia	ICA	285	473	438	422
Ecuador	INIA	176	208	200	238
Guatemala	ICTA	139	121	119	164
Mexico	INIFAP	1,722	2,160	1,716	na
Panama	IDIAP	69	133	123	124
Paraguay	DIEAF	64	112	115	112
Peru	INIA	265	256	170	153
Venezuela	FONAIAP	386	423	491	504
Total		*6,085*	*6,916*	*6,754*	*5,133*

continued on next page

[1]It is not clear whether the decline in agricultural research budgets reflects only the decrease in agricultural development budgets or a decreased priority to research within the agricultural development budget.

Table 1. Estimated Evolution of Public Agricultural Research Investments, 1981-1992 (continued)

		Expenditures (million 1985 PPP $)				
Country	Institute	1981	1986	1991	1992	1992*
Argentina	INTA	75.970	60.166	78.443	84.756	104.509
Bolivia	IBTA	3.742	8.051	9.731	3.189	1.279
Brazil	EMBRAPA	333.238	304.418	436.956	464.294	319.223
Chile	INIA	19.863	28.406	29.926	32.080	20.436
Colombia	ICA	37.161	75.308	47.536	50.037	18.973
Ecuador	INIA	21.870	13.365	9.092	10.976	4.277
Guatemala	ICTA	10.227	9.428	5.239	8.529	4.266
Mexico	INIFAP	264.892	156.246	118.097	na	70.698
Panama	IDIAP	5.747	8.494	6.878	7.525	5.361
Paraguay	DIEAF	7.080	9.322	5.296	4.491	3.000
Peru	INIA	27.030	28.362	22.207	24.887	24.363
Venezuela	FONAIAP	58.427	27.768	41.708	44.229	19.013
Total		*865.247*	*729.334*	*811.099*	*734.993*	*595.218*

		Expenditures per researcher (1985 PPP $ x 1,000)				
Country	Institute	1981	1986	1991	1992	1992*
Argentina	INTA	72.699	58.527	82.128	83.503	102.965
Bolivia	IBTA	42.045	98.179	84.375	27.734	11.122
Brazil	EMBRAPA	211.445	176.566	207.580	221.409	152.228
Chile	INIA	117.531	120.282	144.572	169.735	108.127
Colombia	ICA	96.522	159.213	108.529	118.751	44.533
Ecuador	INIA	124.261	64.255	45.460	46.118	17.971
Guatemala	ICTA	73.756	84.178	44.024	52.007	26.012
Mexico	INIFAP	153.804	72.336	68.821	na	41.199
Panama	IDIAP	83.288	63.867	55.918	60.681	43.234
Paraguay	DIEAF	110.617	83.234	46.056	40.101	26.786
Peru	INIA	107.873	440.850	130.521	162.659	159.235
Venezuela	FONAIAP	151.366	70.062	85.022	87.755	37.724
Total		*142.187*	*105.453*	*120.091*	*108.823*	*86.906*

*In current dollars at market exchange rate.
Note: 1992 is an incomplete figure (Mexico na)
Source: ISNAR Indicator Series database (Pardey and Roseboom 1989).

the estimates vary from country to country, public-sector institutes still represent, on average, two-thirds of the total research expenditure, while the shares of universities and private companies average about 13 percent each. Farmer funding for agricultural research represents about 7 percent.[2] By comparison, the private-sector share of food and agriculture R&D in the US is about 60 per-

[2]There are several caveats to these figures. For instance, the high level of private-sector investment in Ecuador reflects the cocoa research conducted by Latinreco, a subsidiary of Nestlé. In addition, farmer groups in Argentina and Brazil fund some research activities but no data are available on actual amounts.

cent (Klotz et al. 1995), while in the UK it is about 57 percent (Thirtle et al. 1994). The role of the private sector will undoubtedly continue to increase, but it is clear that commitment to a strong public-sector role in agricultural research will also be necessary for the foreseeable future.

Table 2. Estimated Shares of Agricultural Research Expenditure by Public Institutes, Universities, Farmers, and the Private Sector in Selected Countries, 1995 (percentage of total expenditure)

Countries	INIAs	Universities	Farmer groups	Private companies
Argentina	86	5	2	7
Brazil (1991)	65	25	2	8
Chile	75	20	1	4
Colombia (1993)	61	2	29	8
Ecuador	52	5	7	36
Mexico	50	17	5	28
Peru	65	20	10	5
Venezuela	80	10	1	9

Sources: For Argentina, Eduardo Trigo, pers. com.; for Brazil, Contini et al. 1997; for Colombia, Falconi and Pardey 1993; for Chile, Venezian 1995; for Ecuador, Falconi 1992; for Mexico, Reed Hertford, pers. com.; for Peru, Cesar Falconi, pers. com.; for Venezuela, Eduardo Lindarte, pers. com.

The decline in funding for research is paradoxical given the documented high returns to investment in agricultural research. An analysis of more than 100 cases throughout the world in the late 1980s shows rates of return consistently above 40 percent and considerably higher than the cost of capital (Echeverría 1990). There are several potential and interrelated reasons for this paradox which vary from country to country in their importance (Byerlee 1996):

- overall government budget cuts as a result of fiscal austerity;
- lack of understanding by national leaders of the crucial role of agriculture in overall development policies;
- lack of recognition of the public-good nature of much agricultural research;
- withdrawal of support by donors;
- inefficiency of research systems and lack of accountability of NARS to those who fund research and to those who use their research products;
- lack of relevant research outputs from many research programs that have never been evaluated in rate-of-return studies (since such studies have tended to focus on "winners") or lack of communication between research managers and policy makers regarding the impact of research;
- a long-term decline in agricultural commodity prices, which acts as a disincentive to investment in the agricultural sector.

The decline in funding for agricultural research has had a significant effect on research performance. However, financial problems in many research systems also reflect institutional deficiencies in NARS, such that a decline in research quality may result in even less support in the future, plunging NARS research funding into a dangerous downward spiral. There is an increasing need for demand-driven, flexible, effective, and efficient research and extension institutions to cope with the profound effects of policy reforms.

In contrast to such ideal institutions, many NARS are characterized by weak cooperation between the public and private sectors, lack of a strategic vision, a nontransparent priority-setting mechanism, and a declining quality of staff. Institutional research structures that separate research by commodity and discipline, as well as incentive systems that lack accountability in terms of impacts at the farm level, cannot address the new demands on research systems. Moreover, bureaucratic inertia has slowed the adjustments needed in institutional structures. Thus, part of the solution to the funding problem will be to reform the traditional INIA model so that agricultural research becomes a more attractive area of investment for governments, farmers, and the private sector.

The decline in funding for agricultural research partly reflects a reduction in support from external assistance agencies, especially USAID and the development banks. In the past few years, both the World Bank and the Inter-American Development Bank (IDB) have reviewed their loan strategies for agricultural research in the LAC region (e.g., IDB 1992, IDB 1993, World Bank 1992, and Byerlee 1996). These reviews have identified limitations in supporting only INIAs and have emphasized the need for "institutional plurality" and diversified funding mechanisms in the design of future projects.

Financing Mechanisms

New alternatives for INIAs: commercialization of products and services

The funding crisis in agricultural research, coupled with the steady development and consolidation of the market for technological inputs and services, has compelled the INIAs to look for ways to commercialize products and services. This applies to both research products (e.g., breeder seed) and other commercial products and services (e.g., commercial seed and soil testing). The proportion of R&D activities for which at least part of the research costs can be recovered is constantly increasing, not only in research that serves commercial agriculture but also in research on crop diversification and nontraditional exports by the small-farm sector.

Most INIAs have always charged for some of their services, including some publications, soil analyses, and other types of laboratory services and diagnostic tests. What is new, however, is the recent development of specific units within the INIAs to expand cost recovery to research products (e.g., through joint ventures) and specialized technical assistance. The introduction of specific procedures to follow in each circumstance is also new.

The new mechanisms include provisions for how the resources should be shared by the different entities involved. EMBRAPA in Brazil now funds over 8 percent of its budget through these mechanisms, and INTA in Argentina has created Fundación ArgenINTA, primarily to commercialize the products and services developed by the institute. Fundación ArgenINTA also supports scientists, experiment stations, and laboratories in the development of projects and business plans for their specific activities and services.

The potential to commercialize research products depends on the degree to which the technology being produced is appropriable (Cap and Trigo 1995). When there is a low level of appropriability, the institutes have little choice but to fund research activities. As the level increases, private-sector funding should also increase, via mechanisms such as consortia, direct support, and franchising. Finally, where there is a high level of appropriability, joint ventures with private organizations is a useful instrument for sharing funding responsibilities.

There are two major motives for such joint ventures. First, a private company may find it cheaper to contract certain types of research to the public sector than to establish or expand its own research facilities. In this way, it can exploit the highly specialized human and physical resources at some public research institutes. For example, in Uruguay malting companies financed research in the public sector to improve the malting quality of barley for the export market (Box 1).

Second, public-sector R&D organizations, particularly those in the agricultural sector, usually lack the skills needed to mass- produce and distribute the production inputs that embody their research results. This skills gap has frequently been recognized as a major limitation on technology diffusion. An INIA with a potentially marketable product may wish to enter into a joint venture with a private firm to adapt the product to specific markets, to test it widely, and to undertake market development.

Box 1. A Public-Private Joint Venture in Uruguay: Improving the Malting Quality of Barley

Although Uruguay is the largest exporter of malt in Latin America, the total area sown to barley is only 140,000 ha, which is too small to attract private firms to undertake R&D. Because of the export orientation, improvements in the malting quality of barley provide significant value added. To this end, the national agricultural research institute, four malting companies, the university, and a food technology laboratory signed an agreement to cooperate on improving malting quality. The malting companies provided US$100,000 for the public-sector institutions to undertake the research. The funds were largely to cover operating costs. The project has been successful in developing new varieties and management practices that improve malting quality. However, the initial transaction costs were considerable, as several meetings were necessary to decide on the distribution of the research among cooperating institutions and on the allocation of costs among the four malting companies.

Source: Díaz-Rossello 1995.

Joint ventures between public- and private-sector institutions, whereby R&D costs and benefits are shared, are being developed in many countries. Areas of cooperation include genetic improvement, seed production, plant propagation, and veterinary sciences. While currently affecting only small segments of the overall research program, such schemes are bound to grow as market mechanisms become more prevalent in guiding agricultural development and R&D activities. Although contract research, as well as the sale of improved seeds and other research products, can provide INIAs with additional funds, it violates the public-good character of the research organization. Accordingly, much of this type of R&D may eventually be privatized.

Funding university research

Universities have historically accounted for only a small proportion of agricultural research in the LAC region. This has usually been basic research, often funded through a small annual appropriation from the State. A major reason for this low profile has been the shortage of research funds for university scientists. When funds have been made available, generally through a competitive grant system, universities have responded enthusiastically to the opportunity. Chile provides the best example in the region of a university system that conducts a significant share of agricultural research in the country (over 20 percent, Venezian 1995). The establishment of competitive research funds, largely supported by government contributions, has been a major impetus to increasing Chilean universities' involvement in research.

Overall, universities represent an underutilized resource that can be tapped with modest levels of funding to increase the total research output of the country. Given that they already have significant human resources in the form of professors and students, they are a cost-effective participant in research. However, with heavy dependence on competitive funding, they may not be able to develop coherent long-term research programs due to the piecemeal nature of much of the research, the lack of funds for research infrastructure, the short-term nature of grants, and the uncertainty of funding continuity. Nonetheless, with increasing emphasis on biotechnology and information-based research, the role of the universities is bound to grow.

National competitive funds

Based on the experience of national competitive funds for general scientific research, agricultural research funds have recently been, or are currently being, set up in several countries including Chile, Colombia, Argentina, Costa Rica, Mexico, Venezuela, and Brazil. The purpose of these funds is to complement annual appropriations from national budgets, while increasing the accountability of research and researchers. Some funds also aim to improve research resource allocation and technology transfer by promoting more effective linkages between research institutes and agricultural producers. Most funds accept project submissions from INIAs, universities, other public institutions, NGOs, and private firms.

Competitive funding mechanisms at the national and regional levels can make additional research resources available while lowering research-execution costs and encouraging a more demand-driven research system. Such funds may have several contributors: governments, multilateral development banks, bilateral donors, and private-sector organizations. In most cases, the funds operate on a depleting basis, usually lasting four to six years, unless they are established as endowment funds. Because they consume only the proceeds of investments, endowment funds have the advantage of providing resources on a continuing basis.[3] However, large up-front investments are needed to generate sufficient annual income to fund a significant research program.

Existing competitive funds are of two kinds. The first finances scientific research through grants to projects, allocated on the basis of scientific merit and congruence with broadly defined agricultural research priorities. These funds are usually administered by national research councils or similar institutions and they cover all economic sectors.

The second type of fund promotes innovation and technology transfer by facilitating linkages between existing R&D capacities in the public sector (including universities) and the production and marketing capabilities of private companies. The allocation of funds is based on the potential economic impact of the proposed R&D. Most funds of this kind have been developed with the assistance of projects supported by IDB and the World Bank. These projects aim to compensate for the fact that Latin American capital markets are short on venture and risk capital for technological modernization.

Research foundations

Research foundations are another mechanism for funding and conducting agricultural research and transferring technology.[4] There are several types of these nongovernmental organizations. Some execute research, usually under contract, while others transfer technology and promote the commercialization of research products. Most foundations focus on the commercial sector, especially export crops and agribusiness. In fact, some foundations such as FUSAGRI in Venezuela have been created by the private sector. There are also foundations involved in development activities beyond agriculture, such as Fundación Polar in Venezuela and Fundación Chile. Although some foundations have endowments, these investment funds aren't usually large enough to support substantial research projects, only a small administrative secretariat.

---

[3]The Regional Fund for Agricultural Technology is an innovative example of an endowment fund being set up for the Latin America and the Caribbean region. National, regional, and international research organizations (or a consortia of them) will compete for funding to conduct strategic public-good type research (Echeverría et al. 1995).

[4]In developed countries, these foundations are mainly philanthropic, providing support for research activities worldwide.

Foundations in the LAC region fall into three basic categories: those that both fund and execute research; those that act as intermediaries for research funds but are not involved in implementing research; and those that seek to link scientific and technological capabilities with R&D needs and investment projects. The first category includes the more mature and financially independent organizations, most of them endowed and evolving from the private sector, such as FUSAGRI, POLAR, and FHIA (Honduras). The second group arose out of a growing concern by donor agencies, especially USAID, about the efficiency and efficacy of national research institutes. The main objectives of these foundations are to channel donor resources to programs and projects in national research institutions, strengthen their management capabilities, and monitor research execution. Only two organizations currently fall into the third category: Fundación Chile and ArgenINTA. Here, the objectives are to facilitate resource mobilization and link research and technological capabilities with innovation and investment opportunities.

USAID has promoted the development of several agricultural development foundations to channel funds to agricultural research in the LAC region. Examples are the Jamaica Agricultural Development Foundation (JADF), created in 1984, and the Foundation for Agricultural Development of Ecuador (Box 2).[5] These institutions were created to strengthen training, technology transfer, and adaptive research to satisfy the needs of small- and medium-scale farmers.

Box 2. A Private-Sector R&D Foundation: FUNDAGRO, Ecuador

With funding from USAID and, later, from other bilateral and multilateral donors, the Fundación para el Desarrollo Agropecuario (FUNDAGRO) was created in 1987 as an alternative to the public research institute. Because of the initial dependency on USAID project funding, FUNDAGRO was rather supply-driven. As the original source of funding decreased (USAID granted a total of US$7 million from 1988 to 1993), the foundation developed a more demand-driven agenda based on a competitive research grants program. With the foundation's assistance, producers or their representatives and commercial agribusiness firms define a research need and invite proposals from researchers in the private sector, the national agricultural research institute, and universities. The winning proposals receive competitive grants to cover a portion of the research costs. In addition to funding research through grants and contracts, the foundation conducts some applied research in-house. The most common research topics supported by the foundation include varietal introduction, adaptation and evaluation, disease and pest control, and crop management. FUNDAGRO has a small endowment fund and has invested in two joint ventures that have generated some income: an organic baby lettuce project and a demonstration farm (Granja Babahoyo).

Source: Byrnes and Corning 1993 and Chang 1995.

[5]Besides JADF and FUNDAGRO, USAID promoted the creation of similar foundations in the Dominican Republic (FDA), Peru (FUNDEAGRO), and El Salvador (FUSADES), in the 1980s (Chang 1995).

The intention was to create organizations with a strong client and private-sector orientation (e.g., through representation on governing boards) and with sustainable funding (e.g., through endowments). After more than a decade of activities, most USAID-promoted foundations have made progress in responding to donor priorities. However, they have not diversified their funding sources, their client support is rather weak, and there is a need to improve their administrative and financial management (Sarles 1990 and Byrnes and Corning 1993).

Since USAID support for foundations has decreased substantially, most have reduced the scope of their programs and are currently attempting to diversify their sources of funding. The INIAs too are redefining their roles and sources of funding. As some of them become smaller, more demand-driven, and more independent of civil service regulation, the distinction between the INIAs and the foundations is becoming blurred. There is a risk that, while chasing funds and working for quick payoffs, some foundations will act more like agricultural development consulting firms rather than research-funding institutions.

Farmer organizations and financing

Direct funding of research by farmers and other consumers of research products has obvious appeal for a number of reasons:

- Farmer contributions *may* increase the total funds available for research.
- By linking funding to output, those who benefit most from research will pay more, making for a relatively equitable system.
- Direct funding by farmers provides a convenient vehicle for promoting a more demand-driven research system, i.e., one in which farmers and other clients directly influence research priorities.

Farmer-financed systems may be organized by commodity or geographic region. Farmers commonly pay a small levy on the output of a given commodity to finance research on that commodity. The system is most developed in Colombia, where research on several important commodities, such as rice, coffee, and sugar, has been funded for a number of years by farmer contributions (Box 3).

An alternative is for farmers in a particular region to pay a small levy on the output of all agricultural produce. The funds then go to support research at a research station that serves that region.

In either case, the funds contributed by farmers may be matched by government funds to encourage farmers to contribute. To date, the most ambitious arrangement for farmer funding of research is found in Uruguay. There, farmers pay 0.4 percent of the value of most agricultural output to support a reformed INIA. These funds are matched by an equal contribution by the government. With this system in place, the INIA of Uruguay has been able to double its budget within five years. A similar but more decentralized system is under discussion in Colombia.

Box 3. Farmer-Financed R&D: Commodity Associations in Colombia

Producers' associations in Colombia impose levies to fund applied research and technology transfer for the crop on which the levy is collected. The oldest and most important among them is a coffee producers' association. It uses the revenues of an export tax to fund research, extension, marketing, rural development, and crop diversification. Similar producer organizations and levy systems have since been established for rice, other cereals, and cocoa. However, since these crops are not exported, a fixed levy is collected when farmers sell their produce. In addition, associations exist for sugarcane and oil palm, but the levy on these crops is voluntary and based on crop area.

There are various institutional arrangements for applying the funds. Some producer associations operate research units with their own infrastructure and research staff (e.g., the coffee, rice, and sugar associations). Other associations fund strategic research by the public research institute, while conducting their own on-farm testing, technology transfer, and extension (e.g., the cereal, cocoa, potato, and oil palm associations). In other instances, the associations import technology if the relevant knowledge does not exist at the national level (e.g., for bananas, flowers, and cotton).

Source: Posada 1992.

Private companies

Private companies conduct research on technologies when they perceive an opportunity to appropriate the benefits. This type of research has a long history when it comes to products that can be protected through trade secrets (e.g., hybrid seed). More recently, liberalization of agricultural input markets and reinforcement of laws on intellectual property rights have encouraged further investment by the private sector (Falconi and Elliott 1995). Private firms investing in R&D have traditionally been agribusiness firms involved in the agricultural input industry. However, new arrivals on the R&D scene include industrial biotechnology firms looking for opportunities in agriculture.

With a few important exceptions, the agribusiness firms investing in R&D have generally been multinationals interested in adapting technology from their global operations to local conditions. Due to the opening of borders and because countries are looking to attract private capital, the climate for private-sector R&D is much more favorable today than a decade ago. Although the total share of private companies in the region's R&D is probably still less than 15 percent, they have significantly increased research intensity in some areas such as hybrid seed (Falconi and Elliott 1995). For example, sales of hybrid maize seed by private seed companies in Mexico more than doubled with the opening of the seed market in the early 1990s (López-Pereira and García 1994). Similarly, Brazil's AGROCERES has a substantial investment in hybrid breeding, amounting to 7 percent of seed sales or a research intensity of about 1 percent of the value of related agricultural production (Box 4). Given that the overall research intensity in the region averages 0.5 percent for all types of research

Box 4. Private Investment in Agricultural R&D: AGROCERES, Brazil

AGROCERES was founded in the 1950s to produce hybrid maize seed. It has grown and diversified to reach total sales of $125 million. In a country where many multinational agribusiness companies operate, the company has been able to maintain more than a 40-percent share of the hybrid seed market and one-third of the market for poultry genetic stock. Currently, AGROCERES invests 7 percent of its seed sales in research, which amounts to a research intensity of at least 1 percent of the value of production. It has been known to contract some of its long-term more strategic research to local universities.

Although AGROCERES has developed largely in the Brazilian market, it operates in the global arena as well. It has purchased user licenses for technology developed abroad and built strong alliances with multinationals. The company licenses its own technology for sales in other countries of the LAC region.

The company pays competitive salaries, promotes career development for researchers, and grants study leaves for short-term training.

Source: Ney Bettancourt, pers. comm., 1995.

(breeding and crop management), the Brazilian figures indicate a substantial contribution of private firms to increasing resources available for R&D on hybrid crops.

An interesting example of a local company investing in R&D is BIOCIDUS in Argentina. The company has developed a market for pharmaceuticals based on biotechnology, achieving a significant export orientation in the process. BIOCIDUS is now looking to make better use of its human and physical capacity by diversifying into agricultural research products based on plant material propagated through tissue culture. The company's R&D costs were higher than sales in the early years and, even after sales took off, they still average 30 percent of total sales.

Toward sustained and diverse financing

Public research institutes in the LAC region are developing several alternative sources of funding. Most INIAs have mechanisms for commercializing research results through alliances with the private sector, especially joint ventures for funding and execution of research. However, commercialization is only relevant where the benefits of technology can be appropriated; thus, this source of funds will account for only a small share of the total budget of institutions specializing in public goods. In addition, the often high costs of commercialization can reduce the net resource gain from this strategy.

A more promising and increasingly popular source of funding in the region is farmer-managed levies on agricultural production. These funds can be used to pay for research conducted by the commodity associations themselves or by outside organizations, whether public or private. Their impact would increase if there were a legislated commitment by governments to match the funds provided by farmers. However, at this stage it is not clear to what extent these levies on farmers and matching grants are truly new sources of funds as opposed to mere substitutes for funds from general taxation. Perhaps more important, levies can foster a demand-driven research system whereby farmers participate in priority setting and impact monitoring. INIA-Uruguay is an example of an organization that changed its organization and management and increased its budget through a combination of farmer funding and matching State grants. This experience suggests it may be possible to find a sustainable and client-driven public-private funding mix.

During the 1980s, some donors and LAC countries shifted emphasis from the INIAs to research foundations as an alternative means of funding and, in some cases, executing agricultural research. To date, the record of foundations has been mixed. There is indeed a role for foundations in facilitating the commercialization of technological services and products of public-sector institutions. Fundacion-Chile is an example of an institutional arrangement that fosters effective links between innovation opportunities and R&D capabilities. Foundations that enjoy national and local funding support and have an endowment will probably continue to be important players in the R&D system. Those that depend heavily on outside sources of funds, such as donors, are likely to decrease in importance, especially as the new INIAs emerge to provide an attractive alternative.

It is clear that the INIAs, while trying to achieve greater institutional diversity and efficiency, will have to seek a bigger share of their funding through competitive bidding schemes. National competitive funds for the development and transfer of agricultural technology are on the rise in the LAC region, and they have proved to be effective and efficient mechanisms for funding research. Indeed, enthusiasm for these schemes is so great that they threaten to become “the new model” for administering public research funds across the board.

Competitive funds can help improve research quality and accountability to funding sources, but they do not generally contribute to institutional development. R&D institutions that already have the research infrastructure are likely to gain the lion’s share of the funds. For this reason, competitive funds may favor more basic science in public research institutions, especially universities. In addition, the short-term nature of most competitive grants is inconsistent with long-term research which requires sustained and stable sources of funding over many years.

The importance of investing in technology applications (in all sectors, not only agriculture) must also be recognized. In today’s world, lack of funding for this is probably a more serious restriction on innovation than lack of funding for research itself. The Fondo Tecnológico Argentino (FONTAR) is a good example of a competitive fund for applied research aimed at facilitating innovation at the level of the firm. Work is executed directly by private-sector firms or by public research institutes that provide services to the private sector. This fund is designed to overcome deficiencies in local capital and insurance markets.

As with research foundations in the 1980s, the proliferation of competitive funds largely financed by donors raises questions about their long-term sustainability. Not only is it unclear how these funds will be replenished at the termination of the donor-assisted project, there is also a real danger of favoring a donor-driven research agenda.

The growing number of funding options for public-sector research is complemented by increased funding and execution of research by private companies. This has been stimulated by market and trade liberalization throughout the LAC region and by a strengthening of intellectual property rights. However, the lack of well-developed financial markets has slowed the evolution of this sector. In addition, there is a clear delineation between multinational firms and small- and medium-sized national and regional companies. Benefiting from access to global markets, nultinationals can exploit economies of size and scope in R&D (both strategic and applied) and operate somewhat independently of public-sector research institutions. With a few exceptions, national companies will require greater interaction with public-sector research if they are to develop their own more applied R&D capacity and compete effectively with the multinationals.

The new funding mechanisms, such as farmers' funds, competitive grants, and commercialization of research products, have arisen in response to an acute shortage of funds to cover the operating costs of research. Meanwhile, dwindling government appropriations are largely spent on salaries. Unfortunately, between the two there is little money left over to maintain the existing research infrastructure or to invest in new physical and human capital for emerging areas of agricultural science such as biotechnology. If research managers used full-cost accounting, the new funding mechanisms would earn enough overhead to cover infrastructure maintenance. But this rarely happens. This notwithstanding, investment in new infrastructure should come from public-sector sources and be a priority for any increased allocations to research.

Although the NARS of the LAC region are going through a turbulent period, we are witnessing the initial stages of a transition to new institutional models. These structures will have to be flexible enough to adapt to changing market conditions. Fortunately, the various funding options reviewed in this chapter should help each institution to stake out a niche in the new system. Nonetheless, public funding of agricultural research, whether through direct appropriations or competitive grants, must be given higher priority in government budget allocations. This is crucial if LAC countries are to improve their competitive position in world markets, meet the growing demands of small farmers, and respond to environmental issues.

References

Byerlee, D. 1996. Strategic Issues for Agricultural Research Policy to 2000 and Beyond. Draft. Agricultural and Natural Resources Department and Office of Agricultural Research and Extension, World Bank, Washington, DC.

Byrnes, K. J. and S. L. Corning. 1993. Programming for Sustainability: Lessons Learned in Organizing and Financing Private Sector Agricultural Research in Latin America and the Caribbean. Draft paper. Rural Development Division, Office of Development Resources, Bureau for Latin America and the Caribbean, USAID, Washington, DC.

Cap, E. J. and E. J. Trigo. 1995. Nuevas alternativas de financiamiento dentro de las instituciones públicas de investigación agropecuaria. Paper presented at the workshop "Enfoques Innovativos para el Financiamiento de la Investigación Agropecuaria en America Latina". Fundación ArgenINTA, Buenos Aires.

Chang, J. F. 1995. Las Fundaciónes de apoyo a la investigación agropecuaria. Paper presented at the workshop "Enfoques Innovativos para el Financiamiento de la Investigación Agropecuaria en America Latina". Fundación ArgenINTA, Buenos Aires.

Contini, E., A.F.D. Avila, F.J.B. Reifscheneider. 1997. *Cademos de Ciensio dan Technologia* 14(1): 57-90.

Díaz-Rossello, R. 1995. Relacionamiento de un INIA con la agroindustria. El caso de la cebada malteada en Uruguay. Paper presented at the workshop "Enfoques Innovativos para el Financiamiento de la Investigación Agropecuaria en America Latina". Fundación ArgenINTA, Buenos Aires.

Echeverría, R. G. 1990. Assessing the Impact of Agricultural Research. In *Methods for Diagnosing Research System Constraints and Assessing the Impact of Agricultural Research*. Ed. R. G. Echeverría. Volume II. The Hague: ISNAR.

Echeverría, R. G., H. Elliott, C. Ives, A. von der Osten, and E. J. Trigo. 1995. Effective Financing of Agricultural Research and the Advancement of Science in Developing Countries. Draft Paper prepared for panel discussion at the Third Annual Conference on Environmentally Sustainable Development, World Bank, Washington DC.

. 1995. The Financing Dilemma for African Agricultural Research Systems: New Evidence and Policy Challenges. Paper presented at the Roundtable on Research Policy and Financing in an Era of Adjustment (South Africa), ISNAR, The Hague.

Falconi, C. 1992. Public and Private Sector Interactions in Agricultural Research in Less-Developed Countries: The Case of Ecuador. Discussion Paper No. 92-13. The Hague: ISNAR.

Falconi, C. and P. Pardey. 1993. Statistical Brief on the National Agricultural Research System of Colombia. Statistical Brief No. 6. ISNAR Indicator Series Project: Phase II. The Hague: ISNAR.

Falconi, C. and H. Elliott. 1995. Public and Private R&D in Latin America and the Caribbean. In *Agricultural Competitiveness: Market Forces and Policy Choice*. Eds. G. H. Peters and D. D. Hedley. Dartmouth, UK: International Association of Agricultural Economists.

IDB. 1993. Summary Report on Agricultural Research and Extension. Project Evaluations. Operations Evaluation Office Report GN-1799. Washington, DC: Inter-American Development Bank.

IDB. 1992. El rol de BID en el fortaleciminento do la investigación agropecuaria en America Latina y el Caribe. Washington, DC: Project Analysis Department, Inter-American Development Bank.

Klotz, C., K. Fuglie, and C. Pray. 1995. Private Sector Agricultural Research Expenditures in the US: 1960-1992. USDA Staff Paper. Washington, DC: US Department of Agriculture.

López-Pereira, M. A., and J. C. García. 1994. The Maize Seed Industries of Brazil and Mexico: Past Performance, Current Issues, and Future Prospects. Working Paper, CIMMYT Economics Program. El Batán, Mexico: International Maize and Wheat Improvement Center.

Pardey, P. G. and J. Roseboom. 1989. *ISNAR Agricultural Research Indicator Series: A Global Data Base on National Agricultural Research Systems*. Cambridge, UK: Cambridge University Press.

Posada, R. 1992. The Agricultural Research System of Colombia: A Review. World Bank Report No. 10397-LAC. Agriculture Division, Technical Department. Washington, DC: World Bank.

Sarles, M. 1990. USAID's Experiment with the Private Sector in Agricultural Research in Latin America and the Caribbean. In *Methods for Diagnosing Research System Constraints and Assessing the Impacts of Agricultural Research*. Ed. R.G. Echeverría. The Hague: ISNAR.

Thirtle, C., J. Piesse, and V. Smith. 1994. Agriculture and Food R&D and Technology in the United Kingdom. Discussion Paper. Reading, UK: University of Reading.

Venezian, L. 1995. El financiamiento de las actividades de I&D en el ámbito de la universidad. Paper presented at the workshop "Enfoques Innovativos para el Financiamiento de la Investigación Agropecuaria en America Latina". Fundación ArgenINTA, Buenos Aires.

World Bank. 1992. *Getting beyond the "National Institute Model" for Agricultural Research in Latin America. A Cross-Country Study of Brazil, Chile, Colombia and Mexico.* Latin America and the Caribbean Technical Department. Regional Studies Program, Report No. 20. Washington, DC: World Bank.

Chapter 17
Trends in Financing Asian and Australian Agricultural Research

Philip G. Pardey, Johannes Roseboom, and Shenggen Fan

Introduction

Asian agriculture, like Asian economies more generally, has grown at a healthy clip over the past several decades. In the 1980s, the agricultural gross domestic product (AgGDP) of many of the low-income countries in the region grew annually by 3 percent. For countries such as China and Indonesia, the rate was over 4 percent. This growth was partly due to a continuation of the Green Revolution gains of the 1970s, but at a slower pace. It was also the result of a substantial shift in the pattern of production that saw greater gains for higher-valued horticultural crops and for livestock, fishery, and forestry products than for the staple cereals and root crops.

A sizeable share of the growth in Asian agriculture is due to the new technologies that emanated from national agricultural research efforts throughout the region and from international centers such as the International Rice Research Institute (IRR), the International Maize and Wheat Improvement Center (CIMMYT), and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Despite these past successes, new concerns are being raised about the future (Byerlee and Pingali 1994, Rosegrant, Agcaoili-Sombilla, and Perez 1995): Will the region be able to maintain these past gains and foster the growth needed to feed and clothe the 4.5 billion people Asia is expected to have by 2020? Will it be possible to address the environmental consequences of agriculture in many land- and water-scarce Asian countries? Continued, and indeed expanded, investments in agricultural R&D are seen as crucial to meeting these pressing demands.

Note: The authors would like to thank the Government of Japan for its contribution to the ISNAR-IFPRI Agricultural Science and Technology Indicators project, on which much of the analysis for this chapter was based.

In this chapter we assess the evolution and current status of investments in Asian agricultural R&D, highlighting the differences between countries at different stages of economic development. The next section briefly reviews the institutional development of agricultural research in Asia and presents an overview of investments in agricultural research in the region over the past 25 years. Various measures of national expenditures on agricultural research are presented and discussed. The third section highlights the changing role of industry in funding Asian agricultural research. In the fourth, we detail recent changes in agricultural research funding in three countries at different stages of economic development: China, Malaysia, and Australia. Their experiences reflect the diversity of developments in the funding of agricultural R&D throughout the region. A few conclusions are presented in the final section.

Regional Review

Institutional development[1]

Botanical gardens were instrumental in the initial transfer and screening of tropical crops in Asia throughout the 19th century.[2] Building directly on these institutional precedents, formal agricultural research practices took root throughout the European (particularly British and Dutch) colonies at the turn of the century. The agricultural research structures that evolved were commodity-oriented and cesses on specific commodities became a popular way of financing agricultural research. Menon (1971) claimed that this crop-specific approach, which persisted well after the colonized countries gained independence, led to considerable fragmentation of national research efforts, unnecessary duplication of effort, and neglect of research on food crops and environmental problems. About 1960, many Asian NARS began to centralize and consolidate their agricultural research operations. For some countries, such as India, Pakistan, and Bangladesh, this involved the establishment of an agricultural research council that assumed major managerial and financial responsibilities and often operated its own research entities. In other countries, research activities were combined into a national agricultural research institute that undertook a comprehensive program, often with considerable autonomy from the ministry of agriculture to which it was ultimately responsible (e.g., MARDI in Malaysia and, to a lesser extent, AARD in Indonesia).

Since China, Japan, Korea, and Taiwan were never colonized by Europeans, their research systems have quite different beginnings. With the Meiji Restoration in 1868, Japan opened up to the rest of the world and within four years established its first agricultural experiment station. (Such stations had only just

[1]This section is based in part on Pardey, Roseboom, and Anderson (1991b) and Senanayake (1990).

[2]Botanical gardens in the Asian colonies were established as early as 1768 in India, 1796 in Malaysia, 1810 in Sri Lanka, 1817 in Indonesia, 1822 in Singapore, and 1864 in Vietnam (Headrick 1988).

begun to emerge in Europe.) Several other stations followed, and by the turn of the century Japan had a well-developed research infrastructure by the standards of the time. Japan also introduced agricultural research to Korea and Taiwan, both of which it colonized during the period 1895 to 1945. In all three countries, agricultural research was placed and remains directly under the ministry of agriculture. In addition, the NARS have distinct national and provincial (or prefectural) research entities that mirror each country's political structure.

China established its first agricultural experiment station in 1902. Despite this early beginning, it was relatively slow to develop a coordinated agricultural research infrastructure. Before 1949, only a few isolated agricultural research entities were in operation. This reflected the political instability and rather inward-looking character of the country during the first half of this century. China's agricultural research developed considerably during the 1950s and 1960s after the establishment of the People's Republic. However, it suffered major setbacks during the Cultural Revolution from 1966 to 1976. Currently, the Chinese NARS is best described as a multiministry research system with a series of parallel agencies at the national, provincial, and prefectural levels of government (Fan and Pardey 1992).

During the past decade, the institutional structure of most Asian NARS has been relatively stable. While there have been ongoing internal reorganizations, few countries have undertaken fundamental restructuring of their research systems as was common practice throughout the 1960s and 1970s. Important exceptions to this generalization are the former Soviet States in Asia, such as Kazakhstan and Uzbekistan, where the organization of agricultural research is in transition, or in some instances, turmoil.

During the Soviet period, nearly all applied agricultural research in these countries was conducted by State farms, while the more basic research was done by the Academies of (Agricultural) Science. These national academies were linked to the "federal" Academy of (Agricultural) Science in Moscow. With the demise of the USSR, the national academies were no longer part of a functioning scientific network. In addition, the collapse of the planned economies in these countries severely affected the operations of the State farms, including their research activities. Questions about how best to restructure the State farms have yet to be resolved. Meanwhile, many research programs have ceased to operate effectively because of lack of funds, and the existing research infrastructure is rapidly deteriorating.

Expenditure trends

Investments in agricultural research for the 12 countries included in our sample[3] grew steadily in the 1970s and 1980s (Table 1). Total annual expendi-

---

[3]These 12 countries accounted for 95 percent of Asia's agricultural research expenditures in the period 1981-85 (including those by Australia, Japan, and New Zealand, but excluding those of the former Soviet States in Asia). Our current sample does not cover the former Soviet states or the Pacific Islands states. Funding experiences in these countries may have been quite different from the countries included here. *The sample also excludes New Zealand.*

tures in public agricultural research more than doubled between the periods 1971-75 and 1986-90, from an annual average of $2.7 billion (1985 international dollars) to about $5.6 billion, more than two-thirds of which was spent by three countries: China, India, and Japan.

Table 1. Average Annual Agricultural Research Expenditure

	Agricultural research expenditures						Annual growth[b]	
Countries	1971-75	1976-80	1981-85	1986-90	Latest year	Latest year (in current million US$ at market exchange rate)	1971-80	1981-93
	(million 1985 international dollars)[a]						*(percentages)*	
Bangladesh	51.7	68.8	111.2	131.0	123.8[d]	20.3	6.8	2.7
China	576.9	842.5	1165.3	1,460.0	1,867.6[e]	358.5	8.4	4.8
India	404.4	657.6	874.6	1,296.5	1,561.8[c]	425.9	9.9	7.5
Indonesia	61.6	108.0	147.2	202.4	208.2[c]	60.8	9.5	6.2
Pakistan	74.6	111.6	165.7	201.8	198.3[d]	53.0	8.5	3.5
Sri Lanka	19.4	31.8	37.3	31.3	35.5[e]	8.4	9.6	-1.3
Low-income	*1,188.5*	*1,820.3*	*2,501.4*	*3,323.0*	*3845.3*[c]	*926.9*	*8.9*	*6.0*
Malaysia	42.7	91.2	124.5	151.0	170.5[d]	93.3	16.1	3.6
South Korea	44.3	53.2	73.9	91.8	127.2[e]	130.6	3.6	6.0
Taiwan	71.8	101.9	145.0	211.9	316.1[d]	359.5	7.2	7.4
Thailand	119.4	143.8	196.9	245.6	428.0[e]	219.9	3.9	8.3
Middle-income	*278.3*	*390.0*	*540.3*	*700.3*	*1039.3d*	*8,03.3*	*6.8*	*6.4*
Australia	239.0	271.7	299.7	290.0	302.0[e]	328.5	2.1	-0.3
Japan	974.0	1,101.2	1,239.9	1,306.5	1,409.6[e]	3,174.1	2.7	1.3
High-income	*1,213.0*	*1,372.8*	*1,539.6*	*1,596.5*	*1,711.6*[e]	*3,502.6*	*2.6*	*1.0*
Total	2,679.7	*3,583.2*	*4,581.3*	*5,619.8*	*6,039.6*[c]	*5,232.8*	*6.0*	*4.3*

Note: The expenditure data were derived mainly from secondary sources and build upon earlier work reported by Pardey and Roseboom (1989) and Pardey, Roseboom, and Anderson (1991a). Although our aim is to report expenditures on all agricultural research performed by public agencies, this has not always been possible. In particular, the coverage has been less than complete on research expenditures by the university sector. We have, however, been reasonably successful in achieving consistent coverage over time. Expenditures generally include all salary, operating, and capital costs, irrespective of the source of funding. Agricultural research defined here includes all crop, livestock, forestry, and fisheries research.

[a] To obtain an internationally comparable measure of the volume of resources used for research, research expenditures were compiled in local currency units, then deflated to base year 1985 with a local GDP deflator (World Bank 1995), and finally converted to 1985 international dollars using 1985 purchasing power parities indexes (PPPs) (Summers and Heston 1991).
[b] Growth rates were calculated using a least squares regression method.
[c] 1990 figure.
[d] 1992 figure.
[e] 1993 figure.

For low- and high-income countries alike, growth in agricultural research expenditures slowed during the 1980s compared with the 1970s. In contrast, for three of the four middle-income countries, expenditures grew more rapidly during the past decade, at a rate that surpassed most other Asian countries. Despite the overall slowdown in growth in the 1980s, in most Asian countries agricultural research expenditures grew faster than in countries in other regions of the world.

Research intensities

Comparing a country's agricultural research expenditures with the size of its agricultural sector (that is, its AgGDP) and with total government spending are two useful ways to look at how agricultural R&D investments have evolved.

Table 2 tracks developments in agricultural research spending measured as a percentage of AgGDP, commonly called an agricultural research intensity (ARI) ratio. Several aspects of these ARI ratios are noteworthy.

Table 2. Agricultural Research Intensity Ratios

	Agricultural research expenditures relative to AgGDP				
Countries	**1971-75**	**1976-80**	**1981-85**	**1986-90**	**Latest year**
			(*percentages*)		
Bangladesh	0.13	0.16	0.25	0.26	0.25[b]
China	0.40	0.48	0.41	0.38	0.43[c]
India	0.21	0.33	0.38	0.48	0.52[a]
Indonesia	0.13	0.21	0.26	0.27	0.27[a]
Pakistan	0.39	0.52	0.58	0.59	0.47[b]
Sri Lanka	0.40	0.53	0.50	0.37	0.36[c]
Low-income	*0.27*	*0.37*	*0.39*	*0.40*	*0.39*[a]
Malaysia	0.51	0.85	1.04	1.08	1.06[b]
South Korea	0.27	0.26	0.36	0.39	0.56[c]
Taiwan	1.41	1.70	2.34	3.03	4.65[b]
Thailand	0.73	0.65	0.89	0.94	1.40[b]
Middle-income	*0.60*	*0.65*	*0.89*	*0.94*	*1.34*[b]
Australia	2.56	2.93	3.51	3.11	3.54[b]
Japan	1.97	2.24	2.81	3.03	3.36[b]
High-income	*2.06*	*2.33*	*2.92*	*3.04*	*3.29*[b]
Total	*0.48*	*0.58*	*0.60*	*0.59*	0.58[a]

Note: For details about institutional coverage, see Table 1

[a]1990 figure.
[b]1992 figure.
[c]1993 figure.

Grouping the countries as we have in Table 2 by stage of economic development stratifies them into discernably different investment classes that are not apparent when simple spending totals are used as indicators of investment (see Table 1). There appears to be a fairly close association between research intensity ratio and stage of development or, more concretely, per capita income. The lower-income group had ARI ratios that averaged 0.39 percent in 1990—some nine-fold lower than the corresponding ratios for the high-income countries. ARI ratios for the middle-income group fell between those for the high- and low-income countries. This result is consistent with the strong, positive relationship between ARI ratios and per capita income that Pardey, Roseboom, and Anderson (1991b) found using a much larger, worldwide sample of countries. Growth in ARI ratios for the low-income Asian countries stalled after the late 1970s but continued to increase markedly for middle- and high-income countries.

For the second perspective, we express public agricultural research spending as a percentage of total government expenditures (Table 3). In contrast to the ARI ratios presented above, agricultural research expenditures relative to total government spending declined over time for most of the countries in our sample. Interestingly, government spending ratios declined most rapidly for the high-income countries than for the middle-income countries, and for the lower-income countries, they remained more or less constant. There is a negative relationship between the *rate of change* in government intensity ratios and per capita income. But there is no clear relationship between per capita income and the intensity of government spending on agricultural research as was the case for agricultural research spending relative to agricultural GDP.

Table 3. Agricultural Research Expenditures as a Share of Total Government Expenditures

	Agricultural research expenditures				
Countries	**1971-75**	**1976-80**	**1981-85**	**1986-90**	**Latest year**
			(*percentages*)		
Bangladesh	0.90	0.74	0.84	0.76	0.66[a]
China	0.45	0.51	0.60	0.51	0.54[c]
India	0.63	0.64	0.61	0.59	0.66[a]
Indonesia	0.28	0.27	0.27	0.31	0.29[a]
Pakistan	0.63	0.63	0.67	0.53	0.41[b]
Sri Lanka	0.45	0.44	0.39	0.28	0.29[c]
Low-income	*0.50*	*0.53*	*0.57*	*0.52*	*0.53*[a]
Malaysia	0.53	0.72	0.56	0.66	0.57[b]
South Korea	0.43	0.26	0.25	0.23	0.21[c]
Taiwan	0.91	0.71	0.67	0.62	0.53[b]
Thailand	1.25	0.94	0.82	0.86	1.10[b]
Middle-income	*0.77*	*0.62*	*0.56*	*0.55*	*0.55*[b]
Australia	0.77	0.63	0.59	0.49	0.42[a]
Japan	0.82	0.59	0.52	0.48	0.47[a]
High-income	*0.81*	*0.59*	*0.53*	*0.48*	*0.47*[a]
Total	*0.63*	*0.56*	*0.55*	*0.51*	0.51[a]

Note: For details about institutional coverage, see Table 1.

[a]1990 figure.
[b]1992 figure.
[c]1993 figure.

Industry Funding of Public Agricultural Research

Recently there has been a worldwide resurgence of interest in attracting more industry support for public agricultural R&D. This is by no means a new form of research financing, especially in Asia. Much of the agricultural research that began earlier this century in what today are the less-developed countries of Asia was targeted on commercial export crops. Funding often came from commodity-specific taxes levied on or collected by processors, marketing organizations, and government customs agencies. It was common for these funds to be channeled through commodity boards or committees to pay for services (e.g., promotion, marketing, advice, technology, and research) provided to the respective industry groups. In addition, the processing or marketing of some commodities was controlled by state enterprises whose monopoly profits were used in part to finance commodity-specific research. Such was the case for sugar research in Bangladesh, Indonesia, Sri Lanka, and Taiwan, where sugar processing is still monopolized by state-run enterprises. Similar arrangements were used for tobacco research in Taiwan and Thailand, which have state monopolies for tobacco marketing. Table 4 provides an overview of commodities for which specific funding schemes have existed or are still in operation.

Until 1966, the Indian NARS was financed mainly through commodity-specific cesses and the Agricultural Produce Cess Fund. The latter was established in 1940 to provide revenue for the Indian Council of Agricultural Research (ICAR). An *ad valorem* tax of 0.5 percent was levied on a broad range of agricultural exports. Between 1941 and 1966, this fund generated about three-quarters of ICAR's total revenues (Rajeswari 1992). The commodity-specific research funds were administered by commodity committees or boards. Most of these boards operated their own research facilities, although a few opted to fund research undertaken by state agricultural departments and universities.

These commodity-based financial and institutional arrangements were seen by some as impediments to the development of a more centrally managed and nationally focused agricultural research system in India. Three successive reviews of the country's agricultural research system during the 1950s and 1960s advised that ICAR exercise more direct management responsibility for this commodity research. With the reorganization of ICAR in 1965-66, most of the commodity research institutes were placed under ICAR's management and the commodity check-off schemes were terminated. The exceptions were coffee, rubber, silk, and tea, whose commodity boards continued to administer their respective cess funds and directly manage the research these funds made possible. The Agricultural Produce Cess Fund was continued but its importance as a source of funding for the newly established ICAR declined; the fund now accounts for less than 4 percent of ICAR's revenues.

Table 4. Commodities with Specific Funding Arrangements for Research

Commodity	Bangladesh	India	Indonesia	Malaysia	Pakistan	Philippines	Sri Lanka	Taiwan	Thailand
Arecanut		†1966							
Cashew							X		
Cocoa			X	X[a]					
Coconut		†1966			†1981	X			
Coffee		X	X						
Cotton		†1966			X				
Jute	†1973	†1966							
Lac		†1966			†1981				
Oilseeds		†1966			†1981				
Palm oil			X	X					
Rubber		X	X	X			X		X
Silk	X	X							
Sugar	X	†1969	X			X	X	X	X
Tea	X	X	X				X		
Timber						X			
Tobacco		†1966	X		X	X		X	X
Agricultural produce		X			†1981				

Note: This overview is not exhaustive nor was it always possible to identify cess schemes that are no longer operational. An X indicates that an industry funding scheme is currently in operation, while † indicates that such a scheme no longer operates. Dates signify the year in which the cess scheme was terminated.

[a]Legal provision for collecting a cess exists but has not yet been implemented.

Both East and West Pakistan inherited and maintained similar funding arrangements after being partitioned from India in 1948. However, the Pakistani-based commodity committees administering these funds lost access to the various research facilities located in India. Local research institutes were established for several commercially important crops: jute, silk, sugar, and tea in East Pakistan, and cotton and tobacco in West Pakistan. Check-offs levied on coconut, lac, and oilseeds were earmarked for the Pakistan Agricultural Research Council (PARC) and, together with the Agricultural Produce Cess Fund, constituted a substantial part of PARC's total revenues. But when PARC was reorganized in 1980, the government abolished all cess funds over the objections of the council's management which recommended expanding such funding arrangements. In Bangladesh, the jute cess scheme was terminated in 1973.

Industry-based funding is also an important feature of agricultural research in Indonesia. During the colonial period, several large companies, which owned plantations throughout the country, operated their own research facilities, while smaller plantation owners funded joint research facilities (e.g., those of the Sumatra Planters Association). As a consequence of the nationalization of most Dutch-owned plantations in the 1950s, the Indonesian government now owns and operates a large number of estate enterprises (PTPs) through its Ministry of Estate Crops. The research facilities servicing these estates were continued and funded by the PTPs.

When the Agency for Agricultural Research and Development (AARD) was established in 1974, most of the estate crop research entities initially remained outside it. However, a Board of Management was established in 1979 to coordinate the estate-crop research activities. Gradually, management of the estate crop research institutes was consolidated under this Board. The Board, chaired by the director general of AARD, was affiliated with AARD but not directly controlled by it. In 1986, the Board was divided into two entities: one for sugar and one for the remaining estate crops. These institutional changes were made in such a way that funding by industry has remained the most important source of revenue for estate crops research in Indonesia. In 1990, industry funding accounted for 92 percent of the resources for this type of research. Because estate crops research accounts for just 20 percent of total research spending, the industry share of total research expenditures was about 18 percent in 1990. The remaining 82 percent came from general government revenues and from grants and loans provided by donor agencies.

This brief and partial review suggests that industry-based funding arrangements, once quite common throughout colonial Asia, became less so after independence, with few new schemes being initiated in more recent years. Although several such schemes are still in place, industry contributions currently provide less than 5 percent of total public agricultural research resources in most Asian countries. Indonesia, Malaysia, and Sri Lanka are the only countries with substantial industry funding, estimated, respectively, at up to 18 percent, 29 percent, and 40 percent of total funding for publicly provided agricultural research.

Commodities for which industry-based funding arrangements persist usually have highly concentrated production, marketing, or processing sectors. This lowers the transactions costs involved in collecting industry taxes and ameliorates the free-rider problem; the fewer numbers of beneficiaries makes it less likely that an individual or group of individuals will attempt (or, indeed, be able) to benefit from the R&D without contributing to its cost. Moreover, because many of these commodities are exported in small quantities relative to total world trade, world prices are not affected by research-induced shifts in a country's output. This means that domestic producers of these commodities are likely to be the primary beneficiaries of any research-induced reductions in their cost of production (or increases in outputs and exports). Thus, selfinterest dictates there is economic virtue in the industry taxing itself to fund R&D on its particular commodity.

Country Cases

China

In terms of the number of researchers, the Chinese agricultural research system is the largest in the world, employing more than 60,000 researchers. China's investments in agricultural research grew substantially during the 1970s and the 1980s (Table 1). However, this growth slowed during the 1980s and failed to keep pace with the rapid expansion of agricultural production. As a result, China's ARI ratio declined significantly after peaking at 0.54 percent in 1978. In comparison with other low-income countries in Asia, China moved from investing relatively more than average during the 1970s to about average in recent years.

Funding support for most research institutes in China consists of both core and project funds. Core funds are mainly used for salaries and are allocated to various organizations by central and local finance departments at the various levels of government, on the recommendations of their counterpart Science and Technology Commissions. Project funds are allocated in accordance with the research program specified in the five-year plan.

Until the early 1980s, most funding for agricultural research was provided by government. Only a small proportion came from other sources such as the sale of agricultural produce and services. However, with the introduction of economic reforms in the early 1980s, government policies on agricultural research financing were radically revised. The national government strongly encouraged public research institutes to become less reliant on government funding. As a result, agricultural research institutes have become increasingly involved in income-generating schemes. Some of these draw on in-house scientific expertise (e.g., laboratory analyses and seed production and sales), but others bear little or no relationship to agricultural research (e.g., provision of taxi services). In an effort to stimulate these income-generating operations, the government also encouraged greater links between research agencies and their clients.

Since the introduction of these new funding policies, commercial activities by public research agencies have boomed. In 1987, more than 70 percent of total funding for agricultural research still came from direct government support; 24 percent came from the research institutes' own sources as a result of commercial activities (Table 5). By 1993, however, direct support from the government had dropped to 47 percent, while the institutes' own (self-generated) income had increased to over 40 percent. Although total research expenditures have continued to increase in real terms, the total volume of direct government support to agricultural research declined from 732 million (1985) yuan in 1987 to 695 million (1985) yuan in 1993—a decline of 5.1 percent.

Table 5. Sources of Income for Chinese Agricultural Research Institutes

Year	Level	Share of funds from				Total
		Government	Own income	Loans	Other	
		(*percentages*)				
1987	National	86.2	12.8	0.2	0.7	100
	Sub-national	66.7	26.5	4.2	2.5	100
	Total	*70.5*	*23.9*	*3.4*	*2.2*	*100*
1993	National	68.1	26.2	3.4	2.3	100
	Provincial	45.2	44.1	7.3	3.4	100
	Prefectural	42.8	39.2	13.8	4.2	100
	Total	*47.1*	*40.2*	*9.1*	*3.6*	*100*

Source: Compiled by the authors from the *Agricultural Science and Technology Statistical Materials* (various issues).

The source of funds and the relative importance of those funds in an institution's funding base varies depending on the kind of institution and the region involved. National institutes rely more on government funding than provincial and prefectural institutes. Most of the self-generated income is used to augment the salaries of researchers and provide other fringe benefits. Only a small proportion is used to meet operational or capital costs of R&D.

There are increasing concerns about conflict of interest between the research responsibilities and the income-earning activities of the research institutes. Both human and financial resources are diverted from research to generate additional income and top up salaries. Rozelle, Pray, and Huang (1996), for example, provide evidence that this is undermining the quality and the amount of research. In addition, the research agencies at the prefectural and provincial level that conduct applied and adaptive research have been more successful in diversifying their funding base than the national agricultural research agencies that conduct more basic research. Hence, these new policies appear to be undercutting the country's basic research capacity and shifting the emphasis of its agricultural R&D in ways that could be detrimental in the longer run.

Malaysia[4]

The Malaysian Agricultural Research and Development Institute (MARDI) was established in 1969 as a statutory agency under the Ministry of Agriculture. It is now the country's largest agricultural R&D agency, undertaking research

[4]This section is based in part on Hashim (1992) and Kadir (1994).

on a broad range of crops and livestock. In addition, there are three research entities directly managed by statutory commodity boards operating under the auspices of the Ministry of Primary Industry. They are the Rubber Research Institute of Malaysia (RRIM), established in 1925 and managed by the Rubber Research and Development Board; the Palm Oil Research Institute of Malaysia (PORIM), established in 1979 and managed by the Palm Oil Research and Development Board; and the Research Department of the Malaysian Cocoa Board (MCB), established in 1989. The Ministry of Primary Industry also administers the Forest Research Institute of Malaysia (FRIM), which before 1985 operated as a research unit within the Department of Forestry.

A decade ago most of the funding for MARDI and FRIM was directly provided from general government revenues, while RRIM and PORIM were almost wholly funded by commodity-specific taxes (Table 6). In the case of rubber, there is a cess of M$0.0385 per kg of exported rubber collected by government customs agents, 70 percent of which is earmarked for research conducted by RRIM. Industry support for PORIM research comes from a M$5.00 per ton cess on all the crude palm oil and palm kernel oil produced in Malaysia, whether consumed domestically or exported. The levy is collected directly from oil millers. MCB, established in 1989, has to date been financed from general government revenues. Although there is a provision in MCB's act of establishment that allows for research funds to be generated by taxing the cocoa industry, it has yet to be implemented.

Table 6. Sources of Income for Agricultural Research Institutes in Malaysia

		Share of funds from				
Year	**Level**	**Government**	**IRPA**	**Cess**	**Other**	**Total**
			(*percentages*)			
1986	MARDI	89.2	0	0	10.8	100
	RRIM	0	0	92.3	7.7	100
	PORIM	0	0	100.0	0	100
	FRIM	97.3	0	0	2.7	100
	Total	*46.1*	*0*	*46.4*	*7.5*	*100*
1993	MARDI	70.0	25.5	0	4.5	100
	RRIM	17.2	22.7	52.6	7.5	100
	PORIM	0	7.1	92.9	0	100
	FIRM	71.3	14.2	0	14.4	100
	Total	*44.5*	*20.7*	*29.2*	*5.7*	*100*

Source: Kadir 1994.

During the past decade, the sources of support for agricultural research in Malaysia have changed considerably. In 1987, the government created a special fund for R&D under its so-called Intensification of Research Priority Areas (IRPA) program. Operated by the Ministry of Science and Technology, this is essentially a competitive funding scheme, and all research institutions and universities are eligible to bid for its research funds. Five panels, covering agricultural, industrial, medical, strategic, and social science research, screen proposals for compliance with government policies and objectives, the perceived needs of end users (e.g., industry), and funding availability. A substantial amount of government support is currently channeled through the IRPA program (Table 6).

Another significant change has been the dramatic contraction in the cess income from rubber exports whose volume declined in response to increases in domestic consumption and declines in domestic production. Industry funding for RRIM research dropped from M$59 million in 1986 to just M$35 million in 1992. The shortfall has been met by direct government payments and additional public funds channeled through the IRPA program (Table 6).

Australia

The Australian public-sector agricultural R&D system is particularly interesting for several related reasons. First, Australia invests relatively heavily in public-sector agricultural R&D (nominal research intensities are substantially higher there than in most other industrialized countries). Although Australia provides little direct assistance to its agricultural sector, it provides more support than most countries for public-sector agricultural R&D; most developed countries provide more total assistance but mainly through price support and other direct interventions in commodity markets that have become quite unimportant in Australian agriculture.

Second, mechanisms have progressively developed—from the 1930s to the present—to facilitate a growing role for industry in providing funds and, perhaps to a lesser extent, in setting research directions. In the beginning, the industry R&D funding arrangements were relatively informal. They had evolved in a fragmented manner and lacked a coherent rationale. The past 10 years have seen a dramatic redesigning of Australia's rural R&D system. The intent has been to formalize and strengthen the private sector's role in R&D, both as a source of funds and as a determinant of where the R&D effort should be directed.

This evolution has culminated in the creation of a system of Research and Development Corporations (RDCs) funded by commodity check-offs (or taxes) matched on a formula basis with grants provided by the federal government. The RDCs are now responsible for around 30 percent of total public-sector agricultural R&D in Australia. The RDC model is a mechanism by which the effects of factors leading to underinvestment (public-good characteristics of research, the difficulty of excluding free riders, and the nonrival use of research findings) can be reduced to allow industry, the principal beneficiary, to take more responsibility for the funding and direction of research.

The rationale for introducing the new RDC arrangements in 1985 (and revisions in 1989) was

- to increase the resources available for agricultural research;

- to increase industry support for agricultural research;
- to provide greater opportunities for industry to influence the direction of research.

In fact, the RDCs have not succeeded in increasing the public resources available for agricultural research. Since 1985, while nominal expenditure has continued to rise, real expenditure has remained constant and research intensities have slightly declined. But there is no evidence that the RDCs have crowded out other sources of funds for public-sector agricultural R&D: without rising contributions from the RDCs, total funding for agricultural R&D could well have fallen faster in real terms.

The RDCs have been successful in increasing *industry* support for research. Expenditure by the RDCs rose from A$56 million in 1985 to over $280 million in 1994-95. R&D expenditure by business has also risen markedly. Some of this can be attributed to the RDCs, but some is a response to the 150 percent tax concession for research expenditure. However, the increase in research expenditure has not been enough to maintain the share of agricultural research in the total research budget or relative to agricultural GDP.

In addition, there seems to have been a marked shift away from basic research towards applied rural research, which may not be appropriate. The heavier emphasis on applied rural research in public institutions has presumably come at the expense of more basic research, which has a higher public-good content. The RDCs are, no doubt, responsible for some of this shift. The fact that RDC funding attracts additional public funding adds to the RDCs' influence and raises the question of whether the "tail" of RDC funding is "wagging the dog" of public-sector agricultural R&D expenditures too much. Furthermore, the potential for conflicts of interest raises issues about RDC governance structures. Alston et al. (1995) conclude that, on balance, the rising role of RDCs has been beneficial for the Australian economy, but not without some drawbacks.

Conclusion

Spending on public agricultural research for low-income countries in Asia is now over three-fold higher than in 1971; for middle-income countries there was almost a five-fold increase over this same period. But growth during the 1980s, while still substantial, was slower than the previous decade. And research spending relative to the value added in agriculture stalled in low-income countries in Asia (and for some, like China, it even shrank) during the 1980s given substantial growth in AgGDP in those countries. Middle-income countries in Asia increased their agricultural research intensity ratios, as did the slower growing agricultural economies of the region's high-income countries.

Government spending ratios that express public agricultural R&D expenditures as a share of total government spending give an alternative perspective on support for public R&D. While agricultural R&D spending relative to overall public expenditures is now roughly equal across countries grouped by income class, this has not always been so. Twenty years ago, low-income countries spent considerably less on agricultural R&D relative to total government spending than high-income countries. However, these government spending ratios trended down for the middle- and high-income groups of countries, but not for the low-income country group for which the ratio remained relative constant.

Taxpayers still foot most of the bill for funding agricultural research done by public agencies in Asia. Nonetheless, a variety of alternative funding mechanisms is now in place and there seems to be a fairly widespread trend toward greater private participation in publicly performed agricultural research. The pressure placed on public agricultural research agencies to earn more of their own income may not only affect the composition of their research portfolios, but may also lead to a diversion of research capacity to nonresearch activities as seems to be the case in China. In this regard, the recent developments in China are a reason for concern.

Funding by industry based on commodity levy schemes (with matching funds in some cases), export taxes, and various fee-for-service approaches is being tried for a number of commodities in a number of countries. Industry's influence over how these funds are spent and the mechanisms it uses to oversee research vary markedly across countries and across institutions within a country. The impression is that these organizational and management issues may matter just as much as the amount of resources earmarked for research in terms of economic consequences.

References

Alston, J. M., M. S. Harris, J. D. Mullen, and P. G. Pardey. 1995. Paying for Productivity: Financing Agricultural Research in Australia. Paper prepared for the United States Office of Technology Assessment. Mimeo, Department of Agricultural Economics, University of California, Davis.

Byerlee, D. and P. Pingali. 1994. Agricultural Research in Asia: Fulfillments and Frustrations. Paper presented to the XXII Conference of the International Association of Agricultural Economists, Harare, 22-29 August 1994.

Fan, S., and P. G. Pardey. 1992. *Agricultural Research in China: Its Institutional Development and Impact.* The Hague: ISNAR.

Hashim, M. Y. 1992. The National Agricultural Research System in Malaysia. ISNAR Working Paper No. 41. The Hague: ISNAR.

Headrick, D. R. 1988. *The Tentacles of Progress: Technology Transfer in the Age of Imperialism, 1850-1940.* Oxford, UK: Oxford University Press.

Kadir, A. A. S. A. 1994. Funding Agricultural Research in Malaysia. In *Funding Agricultural Research in Sub-Saharan Africa.* Rome: Food and Agriculture Organization of the United Nations.

Menon, K. P. A. 1971. Building Agricultural Research Organisations—The Indian Experience. In *National Agricultural Research Systems in Asia.* Ed. A. H. Moseman. New York: Agricultural Development Council.

Pardey, P. G. and J. Roseboom. 1989. *ISNAR Agricultural Research Indicator Series: A Global Data Base on National Agricultural Research Systems.* Cambridge, UK: Cambridge University Press.

P. G. Pardey, J. Roseboom, and J. R. Anderson (eds.). 1991a. *Agricultural Research Policy: International Quantitative Perspectives.* Cambridge, UK: Cambridge University Press.

Pardey, P. G., J. Roseboom, and J. R. Anderson. 1991b. Regional Perspectives on National Agricultural Research. In *Agricultural Research Policy: International Quantitative Perspectives*. Eds. P. G. Pardey, J. Roseboom, and J. R. Anderson. Cambridge, UK: Cambridge University Press.

Rajeswari, S. 1992. The Organisation of Agricultural Research in India: An Economic Analysis of Technology Generation, 1860-1990. PhD dissertation, University of Kerala, Kerala, India.

Rosegrant, M. W., M. Agcaoili-Sombilla, and N. D. Perez. 1995. Global Food Projections to 2020: Implications for Investment. 2020 Discussion Paper No. 5. Washington, DC: International Food Policy Research Institute.

Rozelle, S., C. Pray, and J. Huang. 1996. Agricultural Research Policy in China: Testing the Limits of Commercialization-Led Reform. Paper presented at the Post Conference Workshop on Agricultural Productivity and R&D Policy in China, as part of the Global Agricultural Science Policy for the Twenty-First Century, Melbourne, Australia, 26-29 August 1996.

Senanayake, Y. D. A. 1990. Overview of the Organization and Structure of National Agricultural Research Systems in Asia. ISNAR Working Paper No. 32. The Hague: ISNAR.

Summers, R., and A. Heston. 1991. The Penn World Table (Mark 5): An Expanded Set of International Comparisons, 1950-1988. *The Quarterly Journal of Economics*, May 1991.

World Bank. 1995. *World Tables 1995*. Diskette version. Washington, DC: World Bank.

Index

J

L

M

N

O

P

R

S

T

U

V

W

Z

Produced by ISNAR Publication Services

Cover design: Richard Claase
Editing: Gerry Toomey
Contributing editor: Jan van Dongen
Layout: Fionnuala Hawes
Printing: Rapporten Service Drukkerij b.v., Rijswijk, The Netherlands

In spite of high payoffs, agricultural research in many developing countries faces severe financial difficulties. Research leaders need to improve policies, to increase resource mobilization, and to upgrade the management of scarce financial resources.

Financing Agricultural Research: A Sourcebook weaves together an assessment of the current research financing situation with a review of available policy options, strategies for improving resource mobilization, and means of enhancing financial management. It is targeted towards leaders of national agricultural research systems, research center directors, heads of research coordinating bodies, as well as those responsible for approving and assigning resources to agricultural research. Research leaders from other sectors may also find answers to the financing issues that they are facing.

The book is divided into four sections. They examine key policy options available in today's competitive financing environment, review strategies for improving resource mobilization, look at financial management practices in public research institutes, and review public agricultural research finance in the developing world.

ISBN 92-9118-035-1

isnar

International Service for National Agricultural Research

Laan van Nieuw Oost Indië 133, 2593 BM The Hague
P.O. Box 93375, 2509 AJ The Hague, The Netherlands
Tel: (31) (70) 349 6100 • Fax: (31) (70) 381 9677
www.cgiar.org/isnar • Email: isnar@cgnet.com